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UCRL-TR-235536

Categorizaton of Underground Nuclear Tests on Yucca Flat and Climax Mine, Nevada Test Site, for use in Radionuclide Transport Models

G.A. Pawloski
Lawrence Livermore National Laboratory
G. WoldeGabriel
Los Alamos National Laboratory
I.M. Farnham
Stoller Navarro Joint Venture

Report Date: November 2005
Publicaton Date: March 2014

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This work performed under the auspices of the U.S. Department of Energy by Lawrence Livermore National Laboratory under Contract DE-AC52-07NA27344.

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Gayle A. Pawloski
Lawrence Livermore National Laboratory
Livermore, California

Giday WoldeGabriel
Los Alamos National Laboratory
Los Alamos, New Mexico

Irene M. Farnham
Stoller Navarro Joint Venture
Las Vegas, Nevada

Prepared for the Underground Test Area Project
U.S. Department of Energy
National Nuclear Security Administration
Nevada Site Office

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1.0 Introduction

1.1 Prequel

This report was originally written in 2005. Significant time has lapsed since then. This report is being finalized, in its original format, to complete documentation of work at that time. No effort has been taken to update name changes or reference subsequent work.

1.2 Background

The Underground Test Area (UGTA) Project is modeling the migration of radionuclides from underground nuclear tests in order to determine contaminant boundaries for various corrective action units (CAUs) at the Nevada Test Site (NTS). Descriptions of requirements and implementation plans can be found in the Federal Facility Agreement and Consent Order (FFACO, 2005) and corrective action investigation plans identified in the FFACO (USDOE, 1999a; USDOE, 1999b; USDOE, 2000a; USDOE, 2001; and USDOE, 2004). CAU modeling at Frenchman Flat and Pahute Mesa is in progress. The Yucca Flat/Climax Mine CAU is beginning to be addressed.

This report describes attempts to categorize underground nuclear tests in the Yucca Flat/Climax Mine CAU in order to (1) reduce the number of tests that must be individually modeled to develop source term boundary conditions for specific tests and understand processes that contribute to radionuclide migration, and (2) understand the ranges of data and simplified process models that will be utilized in sensitivity studies addressing the source terms for all tests to be applied in the CAU transport model. Hydrologic source term (HST) modeling combines nonisothermal hydrologic flow modeling and mechanistic geochemical modeling (rock–water–radionuclide interactions) to evaluate radionuclide release, retardation, and migration away from the cavity–chimney region in the near field of selected individual tests.

Small-scale simulations provide details that permit understanding of both flow and transport processes. However, these models take significant time and effort to construct and run and are computationally extensive, which precludes addressing every test in a similar manner. Simplified source term (SST) models incorporate distributions of data to represent all tests, or categories of tests, in the CAU, and they rely on the understanding and simplification of complex process models implemented during HST modeling. The simplified models are used to estimate the source term for all tests in a CAU. Unclassified HST models are described in Tompson et al. (1999) for Frenchman Flat and Pawloski et al. (2001) for Pahute Mesa. Reports to date describing simplified source term models for Frenchman Flat include Tompson et al. (2004) and Stoller-Navarro Joint Venture (2005).

The Yucca Flat and Climax Mine underground nuclear testing areas were originally defined as two separate CAUs in the FFACO, but were later combined into a single CAU. The original proposal was to address CAUs individually because the geologic setting of the two local areas is distinctly different. Yucca Flat underground nuclear tests were conducted in alluvium, volcanic and carbonate rocks over the entire basin; Climax Mine tests were conducted in a granitic igneous intrusion in northern Yucca Flat. Particle tracking simulations performed during the regional evaluation indicated that, over the 1,000-year timeframe of concern to the UGTA project, groundwater flow from Climax Mine merges with the much larger Yucca Flat groundwater system (IT, 1996b, d). Smaller-scale contaminant transport modeling also is expected to predict that contaminants from Climax Mine tests will enter the Yucca Flat groundwater flow system within the 1,000-year timeframe. Thus, it was decided to model groundwater flow and contaminant transport from both CAUs together to define the contaminant boundary.

In Yucca Flat, 744 detonations were conducted, and 3 were conducted in Climax Mine, for a total of 747 detonations in shafts and tunnels for the combined CAU (USDOE, 2000b). These numbers apply specifically to underground nuclear tests and exclude atmospheric and cratering nuclear tests. USDOE (2000b) defines a detonation as a single nuclear explosion, noting one or more may comprise a test; a test is defined in the Threshold Test Ban Treaty as either a single underground nuclear explosion conducted at a test site, or two or more underground nuclear explosions conducted within an area delineated by a circle having a diameter of two kilometers and conducted within a total period of time not to exceed 0.1 second. Yucca Flat hosted several types of tests: a single detonation in one emplacement shaft, simultaneous detonations in several emplacement shafts, and simultaneous detonations in the same emplacement shaft. A total of 720 corrective action sites (CASs) applicable to UGTA are located within the Yucca Flat/Climax Mine CAU; detonations that occurred within the same shaft are considered a single CAS (FFACO, 2005).

The UGTA Project is particularly concerned with “saturated” detonations, where the working point (WP, also called the depth of burial or explosion point) of the detonation is below or within 100 m of the water table. This definition was derived by DOE to incorporate the cavity region, which is assumed to be a region influenced by the explosion, for detonations of various yields in a generalized and unclassified way. HST modeling has been restricted to saturated tests. However, simplified source term modeling must incorporate all detonations in a CAU, regardless of the relationship of the working point to the water table. This report investigates both cases.

The Yucca Flat/Climax Mine CAU has many more detonations and more lithologic settings to consider compared to previous CAUs, as shown in the selected data in Table 1.1. Frenchman Flat hosted a small number of detonations (10), all located in similar hydrogeologic settings. Understanding these detonations in terms of flow and transport, regardless of the scales of the models, was relatively straightforward, and no separate categorization task was undertaken.

However, at Pahute Mesa, due to the comparatively large number of detonations and the variety of hydrogeologic settings, tests were categorized (Pawloski et al., 2002) for HST modeling, which was occurring concurrently. Source term modeling of specific detonations on Pahute Mesa was investigated at the CHESHIRE site, in fractured lava and tuff (Pawloski et al., 2001); at the TYBO/BENHAM and ER-20-5 sites, which incorporated many units in the hydrostratigraphic section (Wolfsberg et al., 2001); and at the BULLION site, in altered tuffs (IT Corporation, 1998). Because these efforts by

Table 1.1. Summary of selected information for detonations in shafts and tunnels at Frenchman Flat, Pahute Mesa, and Yucca Flat/Climax Mine corrective action units.

Corrective action unit (CAU)	Number of detonations in CAU	Number of saturated detonations	Announced yield, range, in kilotons (kt)	Working point depth, range, in meters (m)	Working point lithologic range	Possible lithologic layers within emplacement shafts
Frenchman Flat	10	10	<20	175 to 296	9 in alluvium; 1 in tuff	alluvium, vitric tuffs, playa, basalt
Pahute Mesa	82	79	<20 to more than 1 Megaton (Mt)	542 to 1402	vitric tuffs, welded tuffs, altered tuffs, lavas	vitric tuffs, welded tuffs, altered tuffs, lavas
Yucca Flat/Climax Mine	747	170	0-500	58 to 782	alluvium, vitric tuffs, welded tuffs, altered tuffs, carbonate, granitic intrusive	alluvium, vitric tuffs, welded tuffs, altered tuffs, granitic intrusive, carbonates

different contractors seemed to span the possible hydrogeologic settings of detonations on Pahute Mesa, a robust set of HST models was not undertaken. Instead, categorization of tests for SST modeling is being accomplished as part of the transport modeling task.

Work described in this report was undertaken for the Yucca Flat/Climax Mine CAU. It builds on what was learned from previous efforts for alluvial and fractured volcanic rock sites, with the two-part goal of providing categories of detonations for both HST and SST modeling.

1.3 Geologic and Hydrologic Setting of the Yucca Flat/Climax Mine CAU

This summary was taken from the Yucca Flat/Climax Mine CAU hydrostratigraphic framework model (HFM) report (Bechtel Nevada, 2006). Yucca Flat is a topographically closed basin with the Yucca Lake playa at its southern end (Figure 1.1). The basin is bounded by the Halfpint Range to the east, Rainier Mesa and the Belted Range to the north, the Eleana Range and Mine Mountain to the west, and CP Hills and Massachusetts Mountain to the south. Ground elevation in Yucca Flat ranges from about 1,195 m above sea level at Yucca Lake in the southern portion to about 1,463 m in the northern portion of the valley.

Yucca Flat is a Cenozoic basin formed in response to basin-and-range extension. Rocks exposed in the highlands around the margins of Yucca Flat include late Precambrian (Proterozoic) and Paleozoic sedimentary rocks, Mesozoic intrusive rocks, and Cenozoic volcanic and tuffaceous sedimentary rocks.

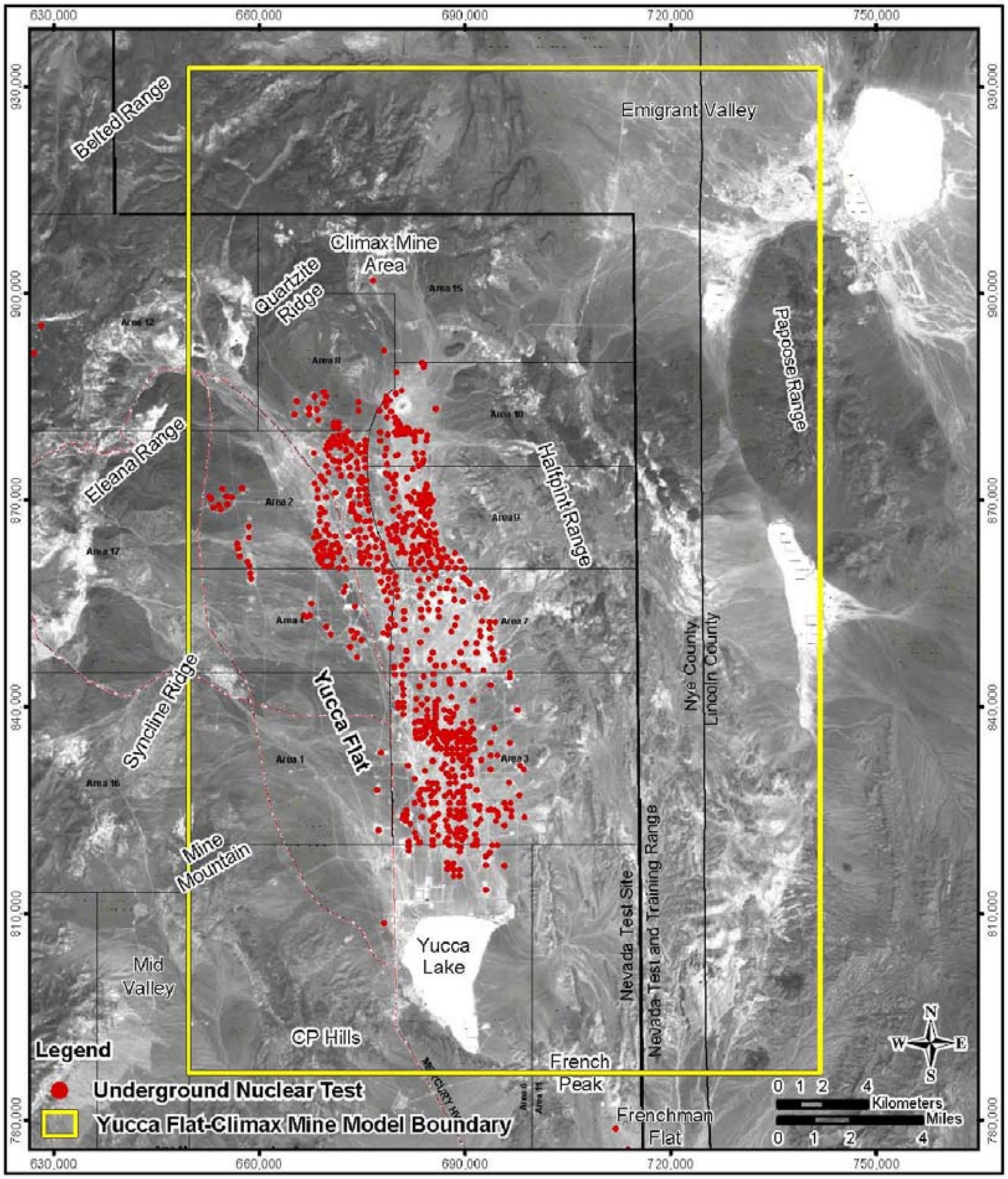

Figure 1.1 Physiographic location of the Yucca Flat/Climax Mine CAU, showing detonation locations.

The oldest rocks exposed in the area consist of Proterozoic carbonate and siliciclastic rocks that outcrop in the northern portion of the Halfpint Range. Paleozoic sedimentary rocks are exposed along the margins of Yucca Flat and consist mostly of carbonate rocks ranging in age from Cambrian to Mississippian. The Paleozoic rocks show contractional deformation most likely related to east- and west-directed thrusting during the Mesozoic (e.g., Belted Range and CP thrust faults). However, contractional deformation has been overprinted by extensional deformation related to basin-and-range deformation during the late Cenozoic (Caskey and Schweickwert, 1992; Cole and Cashman, 1999). During the middle-late Cretaceous, granitic bodies (including the

Climax stock in northern Yucca Flat) intruded these deformed rocks (Maldonado, 1997; Houser and Poole, 1960).

Volcanic rock exposures include Miocene tuffs of generally rhyolitic composition that erupted from large calderas and associated vents located 30 km west of Yucca Flat. These rocks dominate much of the highlands surrounding Yucca Flat. The volcanic rocks include ash-flow tuffs, ash-fall tuffs, and reworked tuff. The thickness and extent of these units vary due partly to the irregularity of the underlying depositional surface, and partly to paleotopography, e.g., barrier to ash flows between Yucca Flat and the source areas to the west. The volcanic and sedimentary rocks are covered in many areas by late Tertiary- and Quaternary-age surficial deposits, consisting of alluvium, colluvium, eolian deposits, basalt lavas, and playa deposits.

Yucca Flat is located within the Ash Meadows sub-basin of the Death Valley regional groundwater flow system, one of the major hydrologic subdivisions of the southern Great Basin (Waddell et al., 1984; Laczniak et al., 1996). Recharge areas for the Death Valley groundwater system are higher mountain ranges of central and southern Nevada, where there can be significant precipitation and snow melt. Groundwater flow is generally from these upland areas to natural discharge areas. Existing data and interpretations from the regional groundwater flow model (IT, 1996b, d) indicate that the overall groundwater flow direction in the Yucca Flat area is from north to south, leaving in the southwest. Regional groundwater flow occurs in both the volcanic formations and the regional carbonate aquifer. The greatest part of groundwater in Yucca Flat moves through the carbonate aquifer. Groundwater from Yucca Flat ultimately discharges at Franklin Lake playa to the south and Death Valley to the southwest.

Because Yucca Flat is a topographically closed basin, no streams enter or leave the basin. Instead, streams are ephemeral, flowing only in response to precipitation events. Runoff is conveyed through normally dry washes toward the topographically lowest areas of the basin and collects on Yucca Flat playa. The water may stand for a few weeks on the playa before evaporating; however, the playa is dry most of the year. Springs that emanate from the local perched groundwater systems are the only natural sources of perennial surface water in the region.

Static water level (SWL) in the Yucca Flat basin is relatively deep, ranging from 153.6 m at UE-1L to more than 580 m in north-central Yucca Flat (Fenelon, 2005). Throughout most of the Yucca Flat area, the SWL typically is located within the lower portion of the volcanic section, in the lower tuff confining unit. In the extreme northern, eastern, and western portions of the area, the SWL can lie within the Paleozoic units. In the deeper structural sub-basins of Yucca Flat proper, the Tertiary volcanic rocks and lower portions of the alluvium are also saturated. Semi-perched water within the alluvium and volcanic aquifers may move downward along faults in the central portion of the basin.

1.4 Hydrostratigraphic Units

Hydrogeologic units (HGUs) categorize lithologic types according to their ability to transmit groundwater, which is a function of their primary lithologic properties, degree of fracturing, and secondary mineral alteration. Hydrostratigraphic units (HSU) are groupings of contiguous stratigraphic units that have a particular hydrologic character, such as an aquifer or confining unit. A HSU may include units of several HGU types, but is defined so that a single type of HGU dominates. The HFM to be used for flow and transport simulations is constructed of hydrostratigraphic units, which provide the basis for incorporating geologic structure as well as hydrologic character.

Hydrostratigraphic data used in this report were derived from the EarthVision® model (Bechtel Nevada, 2006) and are shown in Table 1.2. The table also describes lithology, stratigraphy, and hydrologic significance of each HSU.

Table 1.2 Selected hydrostratigraphic units of the Yucca Flat/Climax Mine hydrostratigraphic framework model[a].

Hydrostratigraphic Unit	Abbreviation	Stratigraphic Unit	Typical Lithologies	Hydrologic Significance
Alluvial Aquifer	AA	Qay, QTc, Qai, QTa, Qp	alluvium; gravelly sand; basalt flows; eolian sands; playa confining unit	Generally unsaturated except in the deepest basins.
Timber Mountain Upper Vitric Tuff Aquifer	TM-UVTA	Tma, Tmab	Vitric nonwelded to partially welded ash-flow and bedded tuff	Typically saturated in only the deepest structural basins.
Timber Mountain Welded Tuff Aquifer	TM-WTA	Tma, Tmab, Tmr	Partially to densely welded ash-flow tuff; vitric to devitrified	Typically saturated in only the deep structural basins. Welded zones are typically sandwiched between non-welded zones. Prolific aquifer where saturated.
Timber Mountain Lower Vitric Tuff Aquifer	TM-LVTA	Tma, Tmab, Tmr, Tmrh, Tp, Th, Tw, Tc, (in northern Yucca Flat may also include Tbgb and Tn)	Nonwelded ash-flow and bedded tuff; vitric	Typically includes nonzeolitized, nonwelded lower portion of the Rainier Mesa Tuff. This HSU can encompass all nonzeolitized, nonwelded, and bedded units below the welded Rainier Mesa Tuff and above the zone of pervasive zeolitization. Unaltered nonwelded and ash-flow tuffs are generally not found much below the static water level due to the tendency to become zeolitized under saturated conditions.
Upper Tuff Confining Unit	UTCU	Tmr, Tmrh, Tp	Zeolitized bedded tuff	Defined to encompass the zeolitized bedded tuffs that stratigraphically overlie the Topopah Spring Aquifer (TSA). Although some units of the UTCU are laterally continuous with those of the LTCU, the UTCU is limited aerially to extreme southern Yucca Flat, where the welded Topopah Spring Tuff is an important aquifer present between two tuff confining units (UTCU and LTCU).
Topopah Spring Aquifer	TSA	Tpt	Welded ash-flow tuff	Distribution limited to extreme south Yucca Flat. Hydrogeologic properties similar to TM-WTA. Prolific aquifers were saturated.

Hydrostratigraphic Unit	Abbreviation	Stratigraphic Unit	Typical Lithologies	Hydrologic Significance
Lower Tuff Confining Unit	LTCU	Tmrh, Tp, Th, Tw, Tc, Tn, Tub, Ton2, To, Tlt	Zeolitized bedded tuffs with interbedded but less significant zeolitized nonwelded to partially welded ash-flow tuffs	Generally includes all zeolitized tuffs in the Yucca Flat area. Stratigraphically the LTCU may include all units from the base of the Rainier Mesa Tuff to the top of the Paleozoic rocks. The strongly argillized older tuffs and paleocolluvium that overlie the pre-Tertiary rocks may also be included. The uppermost zeolitized bedded tuffs overlying the TSA in southern Yucca Flat form a separate HSU (UTCU). This unit is subdivided in Yucca Flat (see below) but not outside of Yucca Flat.
Oak Spring Butte Confining Unit	OSBCU	Tons, To, Toy, Ton1, Tor, Tot	Devitrified to zeolitic non- to partially welded tuffs and intervening bedded tuffs	Identified in the TCU study (Prothro, 2005). Includes altered older ash-flow and intervening bedded tuffs. Welding in older ash flow units may increase overall hydraulic conductivity. Devitrification of ash flows may have limited zeolitization.
Argillic Tuff Confining Unit	ATCU	To, Tlt	Argillic bedded tuffs, minor paleocolluvium	Identified in the TCU study. Includes the argillic, lowermost Tertiary volcanic units, and the paleocolluvium that immediately overlie the Paleozoic rocks.
Mesozoic Granite Confining Unit	MGCU	Kgc, Kgg	Granodiorite and quartz monzonite	Climax intrusive. Low permeability, locally may have perched water contained within fractures.
Lower Carbonate Aquifer – Yucca Flat Upper Plate	LCA3	Dg through Cc	Limestone and dolomite	Includes Cambrian through Ordovician units that have been thrust over the Eleana Formation and the Chainman Shale.
Upper Clastic Confining Unit	UCCU	Mc, Mde	Argillite and quartzite	Typically forms the footwalls of Mesozoic thrust faults in the NTS region. Limited to western Yucca Flat.
Lower Carbonate Aquifer	LCA	Dg through upper Cc	Dolomite and limestone	Important regional aquifer underlying most of southern Nevada. Transmissivity values differ greatly and are directly dependent on fracture and fault frequency.

Hydrostratigraphic Unit	Abbreviation	Stratigraphic Unit	Typical Lithologies	Hydrologic Significance
Lower Clastic Confining Unit	LCCU	Cc, Cz, Czw, Zs, Zj	Quartzite and siltstone	Significant regional confining unit. May present a barrier to deep regional groundwater flow where structurally high. Hydrologic "basement" present at great depth in model.

[a]This table was adapted from Table 4.4 in Bechtel Nevada (2006).

1.5 Phenomenology of Underground Nuclear Tests

The detonation of a nuclear device releases an immense amount of energy that vaporizes the device and rock surrounding the explosion point (Borg et al., 1976; Germain and Kahn, 1968; IAEA, 1998; and Office of Technology Assessment, 1989). High temperatures and a compressive shock wave generated by the explosion produce a cavity and fracture or alter the rock beyond the cavity, as shown in Figure 1.2. The cavity reaches maximum size about 500 ms after detonation. Its size is a function of the energy of the explosion, the depth of burial, and the strength of the geologic media. For tests conducted in the saturated zone, groundwater vaporizes in the immediate cavity region while groundwater mounding may occur further away (Borg et al., 1976; Burkhard and Rambo, 1991; and Knox et al., 1965).

In the seconds and minutes following detonation, temperatures cool, gas pressures dissipate, and components of the cavity gas begin to condense in an order determined by their relative vapor pressures. First among these components are the rock and heavier radionuclide elements that, along with molten rock lining the cavity walls, accumulate as a melt glass puddle at the bottom of the cavity. Within seconds to days after the test, the overlying rock collapses into the cavity, creating a chimney column of rubble that may extend to the ground surface where a collapse crater forms. Groundwater will begin to refill the cavity if the detonation point is below the water table. The high temperatures associated with a nuclear explosion can last many years (Carle et al., 2003).

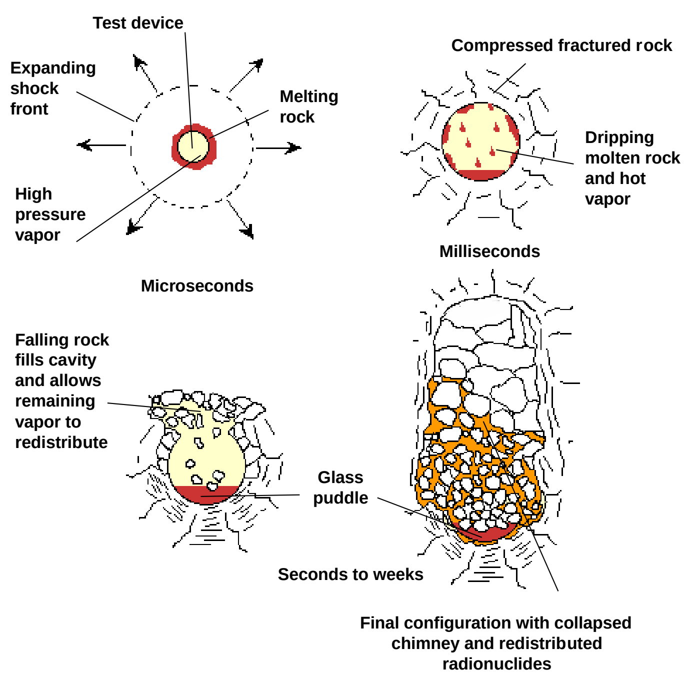

Figure 1.2 Phenomenology of an underground nuclear explosion showing expansion of the shock front, accretion of melt glass puddle, redistribution of more volatile radionuclides—initially as gases, later as condensates—and collapse of the chimney.

1.6 Radionuclide Partitioning and Geochemical Processes

The physical and chemical distribution of radionuclides after an underground nuclear detonation is heterogeneous and a function of the device design, geologic media, radionuclide properties, and cavity growth and collapse history. A number of investigations at the NTS have yielded information regarding the initial distribution of radionuclides after a nuclear test (Kersting, 1996; Smith, 1995; Mathews et al., 1994; Smith et al., 1996; and Thompson, 1996). Tritium is present primarily as tritiated water and is located in the interstitial water. Refractory radionuclides (e.g., Pu, Am, Np, Ce, and Eu) with higher boiling points and lower vapor pressures are largely incorporated in the melt glass that coalesces at the base of the cavity. Radionuclides with boiling points between that of tritiated water and refractory radionuclides (e.g., Sr and Cs) will be heterogeneously distributed in and near the cavity and chimney and in the melt glass. If the melt glass is still molten when rubble above the cavity collapses, the glassy material may splash and distribute refractory material more broadly in the cavity region, while collapsing rubble may become entrained in the melt glass.

The distribution of some fission products is affected by the behavior of its parental precursors. The radionuclides ^{90}Sr and ^{137}Cs are particularly good examples because they have noble gas precursors that can be transported away from the detonation point before their decay to less volatile daughter products (Smith et al., 1996). In some instances, prompt injection of nuclear material along fractures or zones of weakness as the cavity grows may deposit radionuclides outside the immediate vicinity of the cavity and chimney system (Nimz and Thompson, 1992 and Smith et al., 1996).

Geochemical transport processes involving radionuclides in the water, sorbed on rock surfaces, and incorporated in melt glass include aqueous speciation, surface complexation, ion exchange, mineral dissolution/precipitation, and glass dissolution. These processes are handled explicitly or simplified in various models.

1.7 Developing Categories of Tests

The modeled contaminant boundary must include all detonations that contribute radionuclides to it. However, the sheer number of detonations in this CAU makes it impossible to calculate a hydrologic source term for every test. The goal of this report is to (1) recognize characterizing conditions about the setting, both pre-test and post-test, and radionuclide release and retardation over the 1,000-yr timeframe, and (2) assume that differences in host rock, altered settings, and transport mechanisms can be categorized to reduce the total number of detonations necessary to model for both HST and SSM.

General concepts to consider when developing categories of tests for radionuclide transport modeling include:

- The host (pretest) geologic/hydrologic setting.
- The altered setting, partitioning of radionuclides, and transient heat and pressure effects caused by the nuclear explosions (post-test).

- Anticipated transport mechanisms (radionuclide-water-rock interactions).

Evaluating these concepts, independently and in various combinations, will be the basis for developing categories of detonations in the Yucca Flat/Climax Mine CAU.

1.7.1 Pretest Setting

The host setting includes the geologic layers and structural discontinuities. Working points for Yucca Flat detonations were located in carbonate, tuff, and alluvial units. Faults are present in the basin, but were considered a risk to containment of radioactivity, so detonations were typically sited at a distance from known faults. Lithology and mineralogy are used to identify radionuclide retardation reactions for transport. The pretest setting is important to understand because it forms the conceptual model supporting steady-state, CAU-scale flow and transport simulations. This setting is also the basis for imprinting physical modifications caused by the nuclear explosion.

1.7.2 Post-Test Setting

The nuclear explosion produces a shock wave, heat, and pressure, and alters the host rock at roughly radial distances (melt glass, cavity, crush, and rubble zones). Collapse to the surface may occur, forming a rubblized chimney. All of these modifications are dependent on rock strength, saturation, working point depth, and yield. The radionuclide inventory is partitioned in the altered zones to create a zero-time configuration for radionuclide transport simulations. Nuclear explosion heat and pressure create transient effects that vaporize water in the cavity zone and displace and raise surrounding water, impacting the groundwater flow system for varying durations. Establishing convection cells in the low-permeability rubble chimney can permit radionuclides to rise and migrate downstream above the working point depth. Heat and pressure effects are dependent on saturation, permeability, water pore pressure, working point depth, and yield. Test heat also impacts chemical reactions, particularly melt-glass dissolution. Few data are available for high-temperature thermodynamic reactions, but simplified models of temperature-dependent glass dissolution have been developed. Colloids, either existing pretest or created by the explosion disturbance, can accelerate radionuclide migration (Kersting et al., 1999).

1.7.3 Relationship of the Working Point and Static Water Level

The relationship of the cavity region to the water table is important. Many assumptions on radionuclide partitioning, and chemical reactions, including glass dissolution and impacts of test heat and pressure, are derived from saturated scenarios. Tests located above the water table will have different partitioning of radionuclides (larger extents) due to gas-phase transport in the vadose zone. Infiltration through the vadose zone can preferentially focus water through collapsed chimneys, permitting water to reach altered zones and release radionuclides for transport to the saturated zone. Radionuclide release, including glass dissolution, should be slower under partially saturated conditions. Sorbing minerals between the altered zones and water table can potentially retard migration. Faults in both the unsaturated and saturated zone can preferentially focus flow. The ability of test cavities above the water table to contribute radionuclides to the saturated zone is poorly understood. Radionuclide transport under partially saturated conditions has not been investigated by the UGTA Project, but it will influence the source term from many detonations in the Yucca Flat/Climax Mine CAU.

1.7.4 Chemical Considerations

The chemistry of the host rock can affect not only reactions associated with reactive transport, but also the phenomenology (i.e., the interaction of the nuclear explosion shock wave with the surrounding rock) of the detonation itself. With the exception of four detonations in carbonate rock in Yucca Flat, all other underground nuclear detonations occurred in silicate rocks. Our understanding of shock wave dynamics and chemical reactions is based on saturated silicate rocks. Recent HST investigations show that tests detonated in carbonate rock—lacking silicate components—react differently. First, large quantities of high pressure, non-condensible CO_2 gas are immediately generated and expand quickly. Thus, volatile radioncuclides should be partitioned at greater distances at the start of source term simulations. Next, as CO_2 cools, it is heavier than air and can sink downward to the water table, providing potential migration paths. Finally, the melt glass that sequesters large quantities of long-lived radionuclides is not a silicate product, and the chemical reactions for radionuclide release are different than silicate melt glass dissolution.

Radionuclide migration is typically slowed by sorption to reactive minerals in the rock matrix or on fracture linings. Identifying locations and quantities of minerals that react with specific radionuclides will be important in terms of retarding transport.

1.7.5 Spatial Variability Affects

It is important to incorporate such concepts as the spatial variability (heterogeneity) of properties, understanding of the importance of processes at various model scales, and effects of changing scale between models. HST models are typically smaller domains with finer grids designed to evaluate mechanistic processes, while larger-scale models have larger domains with coarser grids and incorporate processes more simply.

1.8 Approach for Categorizing Tests at Yucca Flat/Climax Mine

The objectives of categorizing tests in Yucca Flat/Climax Mine are to:

- Reduce the number of detonations that must be individually modeled to develop source term boundary conditions for specific detonations and understand processes that contribute to radionuclide migration, and
- Understand the ranges of data and simplified process models that will be utilized in sensitivity studies addressing the source terms for all detonations to be applied in the CAU transport model.

These divergent objectives require the acquisition and evaluation of large sets of data related to the original hydrogeologic settings, detonation specifics, and phenomenological behavior. Because categorization of tests occurs after the construction and qualification of the hydrostratigraphic model and before source term, flow, and transport modeling, building upon existing data and models must include conclusions independent of interpretations that occur subsequently.

Attempts have been made to evaluate rock types in a general sense, independent from the flow and transport systems. Hydraulic parameters such as conductivity are not included specifically, but are assumed to be generically incorporated in the definition of hydrostratigraphic units. Other parameters for flow models, such as recharge, discharge, boundary fluxes, and hydraulic heads, are considered to be independent and should be evaluated during flow modeling. Geochemical flow paths are also considered to be independent and are being handled via a separate UGTA investigation. Transport parameters such as sorption, porosity, matrix diffusion, and effective porosity/fracture porosity are also considered to be independent and will be addressed during transport modeling for this CAU. Distribution of the unclassified radionuclide inventory at model time zero will be handled as learned from phenomenological models and previous HST modeling.

In order to understand the pretest setting, data from the hydrostratigraphic model, which is being constructed concurrently with this categorization task, must be obtained and qualified. Understanding the layered sequences and structural settings, with relationship to working points of detonations, is critical. General information about detonation distributions, such as location and timing, must be analyzed. Posttest phenomenologic data—the interaction of the nuclear explosion with the geologic setting—must be acquired from various sources and evaluated. Since there were two agencies sponsoring tests in Yucca Flat/Climax Mine, Los Alamos National Laboratory (LANL) and Lawrence Livermore National Laboratory (LLNL), evaluation of disparate data is key to determining similarities and permitting elimination of administrative or operational differences that are known to exist and have no bearing on phenomenologic behavior. Special cases, such as known sites of prompt injection, or special areas, such as the Area 3 Sand Pile, must be evaluated.

Several issues particular to the Yucca Flat/Climax Mine CAU will be investigated. They are:

- Eliminating detonations that need to be considered as radionuclide sources would greatly reduce the amount of time necessary for transport simulations. This may be done by replicating groups of detonations in similar settings by a single site or omitting detonations that are deemed to be sufficiently above the local water table to not contribute to the source term during the 1,000-year timeframe of concern to the UGTA project.

- Due to the structural shape and layered nature of Yucca Flat, faults may provide “short-cut” paths from sources to aquifers or may juxtapose layers and permit transport that would otherwise not be expected. The large number of detonations and possible close spacing may enhance this effect.

- The extent and thickness of the tuff confining unit (TCU) is important in separating hydrostratigraphic units above it from the regional carbonate aquifer below. The TCU has very low hydraulic conductivity and contains alteration minerals that are known to sorb radionculides and reduce migration.

Only four detonations were conducted below this unit. The ability of the TCU to contain and constrain radionuclide migration is critical to modeling a contaminant boundary for this CAU.

Categorization of test in the Yucca Flat/Climax Mine CAU has been extremely difficult for several reasons:

- Large numbers of detonations. There are almost 10 times as many detonations in the Yucca Flat/Climax Mine CAU as compared to the Pahute Mesa CAU, and about 75 times as many detonations as compared to Frenchman Flat.
- Many combinations of detonation settings combined with layered hydrostratigraphic settings. Differences include varied yields (including zero yield) giving a range of cavity sizes, varied depths of working points within the hydrostratigraphic column, many combinations HSUs over the length of the emplacement shaft and within the two-cavity-radius area of concern, and presence of thrusted carbonate rocks, which raises a regional aquifer.
- Concurrent construction of the HFM (Bechtel Nevada, 2006) with categorization of detonations. Categorization of detonations required information on the hydrostratigraphic setting, including what units are present in the emplacement shafts and those projected between the bottom of the shaft and underlying aquifers. Because the Yucca Flat/Climax Mine HFM is large and complex, it took about a year to develop, construct in EarthVision®, and provide necessary quality checks.[1] Significant improvement has recently been made in stratigraphic identification and nomenclature, but this has made working with old data sets difficult.

1.9 Assumptions

The collection and evaluation of data for detonations on Yucca Flat/Climax Mine CAU included a number of assumptions, including:

- The reader is familiar with the UGTA Project and the geology and hydrology of the Yucca Flat and Climax Mine areas. Further information on these topics can be found in many reports. Gonzales et al. (1998), Gonzales and Drellack (1999), and Bechtel Nevada (2006) specifically discuss Yucca Flat/Climax Mine CAU models developed to support the UGTA Project.
- All data used in this study are unclassified. Yield information has been obtained from DOE/NV—209 Rev. 15 (USDOE, 2000b), the official source of unclassified yield information for U.S. nuclear tests. Specific yields for only a small number of the 747 underground nuclear detonations in shafts and tunnels in Yucca Flat and Climax Mine have been announced. All other specific yield information is classified. For the many detonations that have unclassified yields announced as a range of values, the upper end of the announced yield range is used in this study. As noted in USDOE 2000b, tests

[1] The authors thank Sig Drellack from Bechtel Nevada for his data sets and guidance during the preparation of this project .

with yield identified as “low” have an announced yield of less than 20 kt and the upper end of the yield range (20 kt) is used for this study; tests with yield identified as “intermediate” have an announced yield range of 20 to 200 kt and the upper end of the yield range (200 kt) is used for this study. USDOE 2000b offers no amplification for the term “slight”; 20 kt is used for this study based on instructions from the DOE Nevada Field Office (Hernandez, 2012 personal communication). Cavity radius is calculated from the maximum of the announced yield range and the equation in Pawloski (1999). All yield-related parameters such as scaled depth of burial and cavity radius are thus skewed to the larger value. The calculated cavity radius that identifies the volume of rock affected by the explosion will be the maximum that can be considered.

- The list of detonations used in this evaluation was derived from the Corrective Action Investigation Plan (CAIP) for Yucca Flat/Climax Mine (USDOE, 2000a). The CAIP was used to develop basic information. Minor updates were made for this study, mainly in depth of burial and calculated cavity radius, based on review of data in the LLNL Containment Program and Defense and Nuclear Technologies Weapons Testing libraries.

- Geologic information was derived from the EarthVision® model developed by Bechtel Nevada and Stoller-Navarro Joint Venture (Bechtel Nevada, 2006), including stratigraphy, lithology, alteration, and water level. Stratigraphic contacts were updated and verified for this study by Bechtel Nevada geologists on rare occasions using site-specific information judged to be critical to interpreting the environment near the detonation emplacement shaft.

- Phenomenology—the interaction of the nuclear explosion shock wave with the surrounding rock—is assumed to be consistent for Yucca Flat and Climax Mine detonations, regardless of yield or working point location. Phenomenologic models (Pawloski, 1999) were developed using all data available and generalized to describe the in situ environment after the explosion. The size of the cavity and disturbed zone and the amount of melt glass are calculated using standard equations and the announced yields, as described above.

- The effect of the groundwater system on identifying categories of tests is assumed to be negligible, with the exception that differentiating saturated and unsaturated tests will be included. Instead, the categories are intended to be independent of groundwater gradient or velocity and can be located within a varying groundwater system. The reasons for this are twofold: (1) the flow model for Yucca Flat/Climax Mine is not yet developed, and information does not exist to include in the evaluation, and (2) previous investigations indicate flow fields affect radionuclide migration in a variety of ways. Emphasis will therefore be placed on identifying the permeability of the rocks, which is a parameter in flow models.

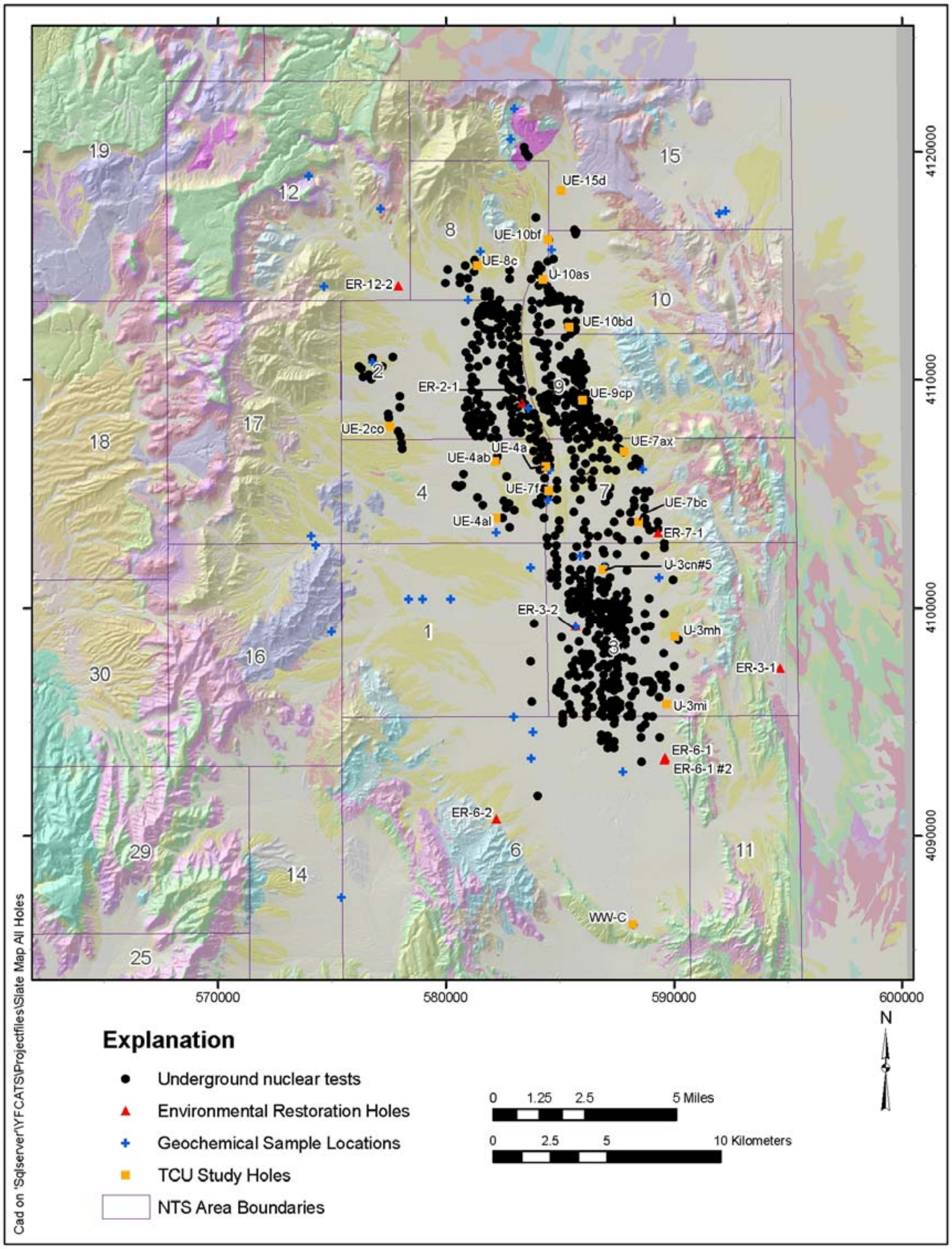

Figure 2.1 Locations of underground nuclear detonations in the Yucca Flat/Climax Mine CAU.

2.0 Analysis of Detonations by Area, Year, and Yield

Appendix A lists all underground detonations in shafts and tunnels in the Yucca Flat/Climax Mine CAU by detonation name, drill hole name, detonation date, emplacement type, purpose of test, announced yield information, comments, and known radionuclide migration information. Appendix A is sorted chronically, identifying the first underground nuclear detonation as PASCAL-A in 1957, and the last as DIVIDER in 1992. The appendix is organized for ease of identifying detonations as they occurred over time.

A small number of drill holes are located in NTS areas other than their hole name displays. Some U-2 holes are located in Area 4; some U-3 holes are located in Areas 6 and 7; some U-4 holes are located in Area 7; some U-10 holes are located in Areas 8 and 9. These cases can be identified by looking at drill hole locations and NTS areas on a map.

Most detonations were emplaced in vertical shafts, while only two are identified as being emplaced in tunnels. In reality, shaft size varied, and some might be more readily identified as tunnel workings or chambers.

Accidental releases of radioactivity were common during the early years of testing. Release information may pertain to an accidental release as a result of containment failure, an accidental or deliberate release as a result of event operations, or a deliberate release as a result of post-test controlled purging of gases from a tunnel (USDOE, 2000b and USDOE, 1996).

Known radionuclide migration data is available for a small number of detonations at the NTS. This information (USDOE, 1992) is included in Appendix A where applicable.

Yucca Flat is unique among CAUs at the NTS in that it hosted simultaneous detonations, which are defined as (1) simultaneous, separate holes—a single detonation or two or more detonations conducted within an area delineated by a circle having a diameter of two kilometers and conducted within a total period of time not to exceed 0.1 second, or (2) simultaneous, same hole—two or more detonations occurring in the same hole within a total period of time not to exceed 0.1 second. In terms of evaluating radionuclide migration, simultaneous detonations in separate holes simply require the appropriate source to be placed in the proper hole and released at the correct zero time. As such, they are treated no differently from any other detonation in Yucca Flat and Climax Mine. Detonations in the same emplacement hole, meeting the definition of simultaneous or not, provide the possibility that multiple cavities or the 2-cavity radius regions may have merged. The status of detonations in the same hole will be investigated in Chapter 5.

2.1 Detonations by Area

Between 1957 and 1992, 747 detonations were conducted in shafts and tunnels in the Yucca Flat and Climax Mine CAU (USDOE, 2000a and USDOE, 2000b). Figure 2.1 shows the locations of these detonations. The figure also includes holes drilled by the UGTA Project for characterization purposes, identification of drill holes used in the tuff confining unit study, and locations of geochemical samples. Of the total number of detonations, 744 were expended in Yucca Flat and three were expended in Climax Mine. The NTS is divided into operational areas. Yucca Flat is composed of Areas 1, 2, 3, 4, 6, 7, 8, 9, and 10, and Climax Mine is located in Area 15. Testing occurred in all areas in Yucca Flat. (Although they appear on maps in this report, Area 17 is called Syncline Ridge, Area 11 is part of Frenchman Flat, and Area 14 is called Mid Valley).

Northern Yucca Flat was assigned to LLNL, while LANL used southern Yucca Flat. Both laboratories sponsored tests in Climax Mine, and both sponsored tests in Areas 4 and 9. Atmospheric and cratering tests were also conducted in Yucca Flat but are not considered part of the UGTA Project and are not included in this report.

Table 2.1 shows that just over half of the detonations in Yucca Flat occurred in Areas 2 (the main LLNL test area) and 3 (the main LANL test area). Only a few detonations were conducted in Areas 1 and 6, while three detonations were conducted in Area 15.

The UGTA Project is particularly concerned with “saturated” tests, where the WP (also called the depth of burial or explosion point) of the detonation is below or within 100 m of the water table. Most saturated detonations were located in Areas 2, 3 and 7. Areas 1, 6, and 8 hosted only unsaturated detonations. Figure 2.2 shows locations of saturated and unsaturated detonations.

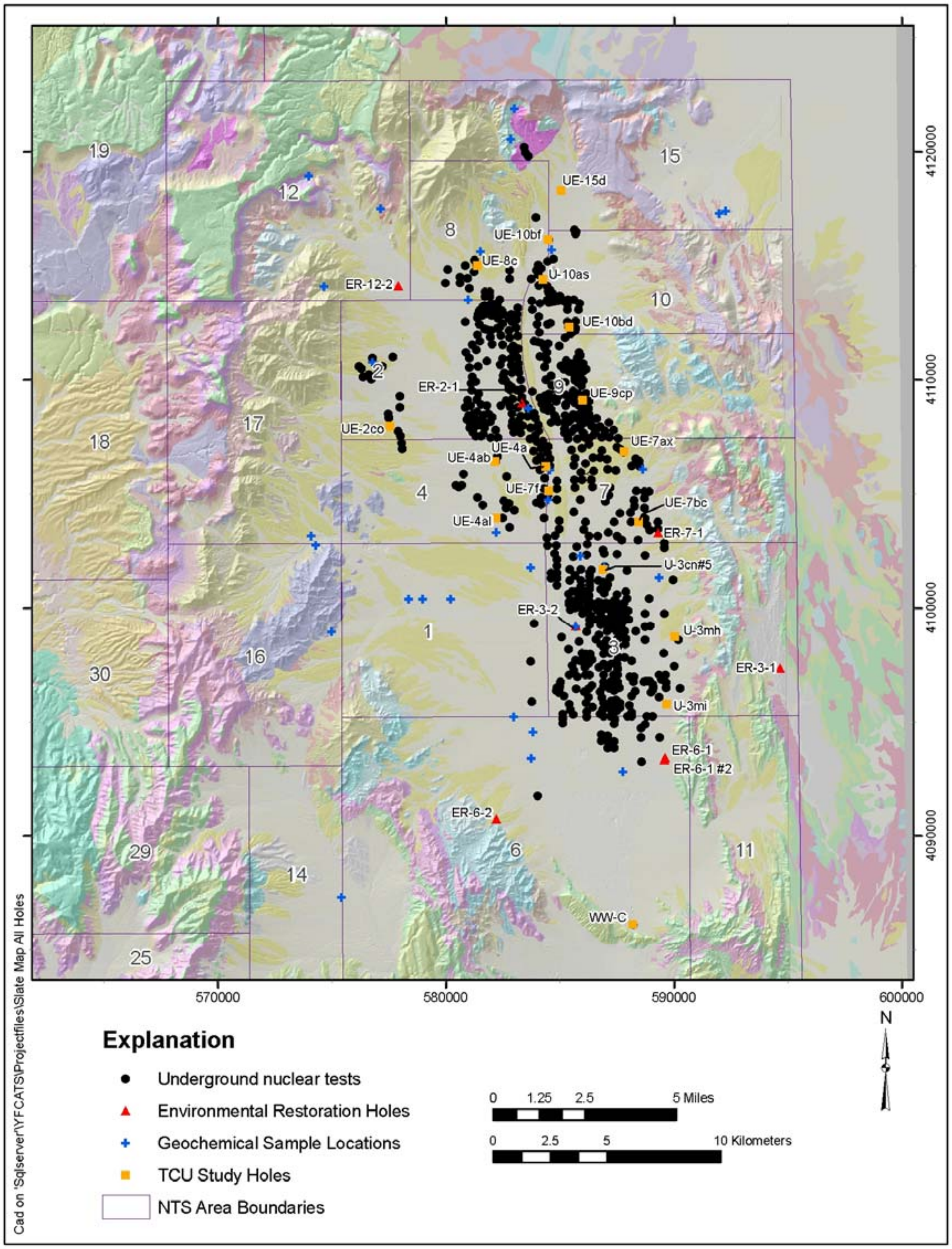

Figure 2.1 Locations of underground nuclear detonations in the Yucca Flat/Climax Mine CAU.

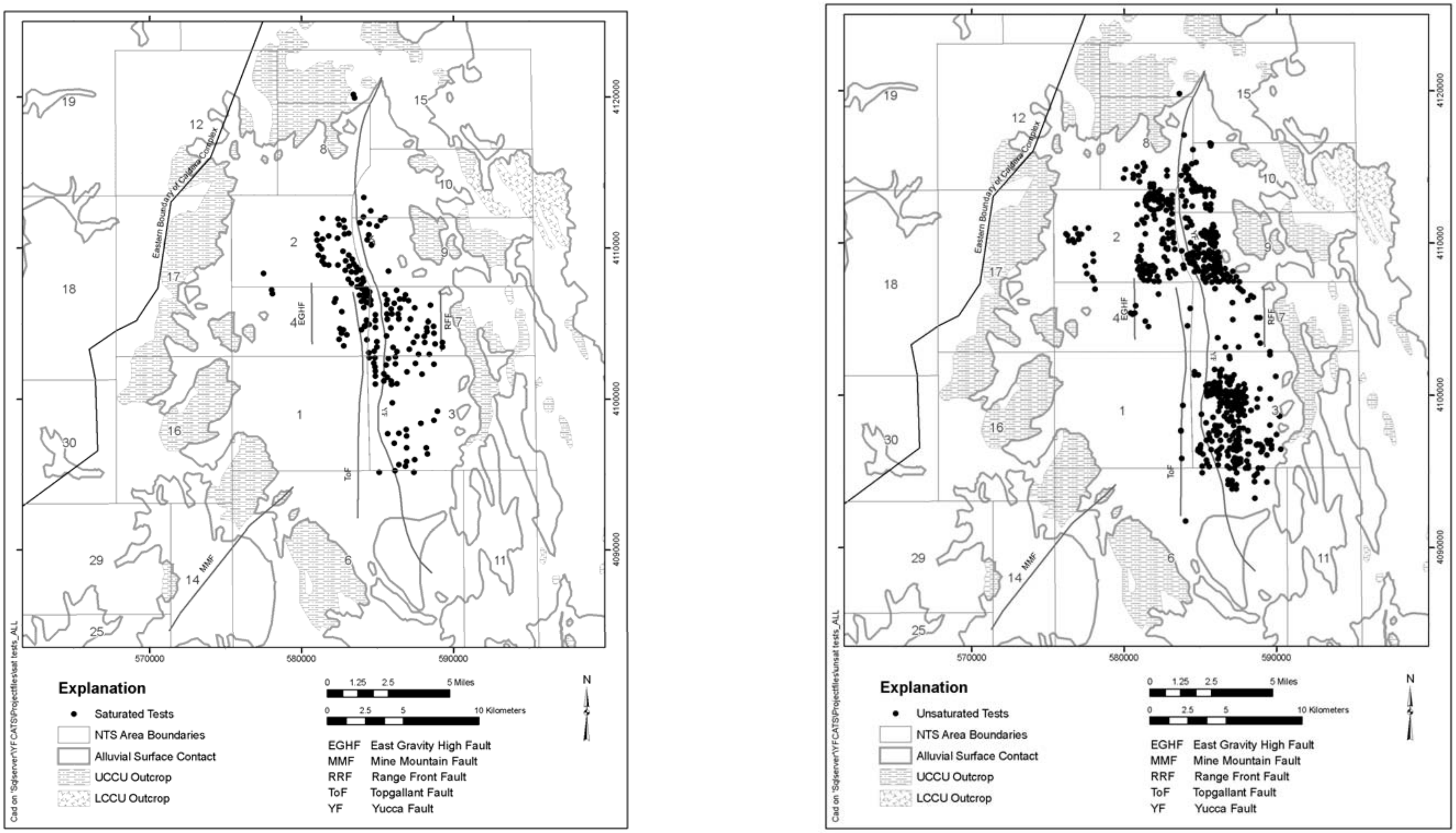

Figure 2.2 Locations of saturated (left) and unsaturated (right) detonations in the Yucca Flat/Climax Mine CAU.

Table 2.1 Numbers of detonations in shafts and tunnels in the Yucca the Flat/Climax Mine corrective action unit.

Area	Total detonations	% Total detonations	Saturated detonations	% Saturated detonations	Unsaturated detonations	% Unsaturated detonations
1	4	0.5		0	4	0.7
2	162	21.7	40	23.5	122	21.1
3	274	36.7	40	23.5	234	40.6
4	39	5.2	29	17.1	10	1.7
6	6	0.8		0	6	1.0
7	62	8.3	47	27.6	15	2.6
8	12	1.6		0	12	2.1
9	118	15.8	5	2.9	113	19.6
10	67	9.0	7	4.1	60	10.4
15	3	0.4	2	1.2	1	0.2
Yucca Flat / Climax Mine	747	100	170	23	577	77

Table 2.2a is a summary of all detonations in shafts and tunnels in the Yucca Flat basin. Tables 2.2b–2.2k summarize, by NTS area, the purpose of detonation, WP hydrostratigraphic unit (HSU), announced yield, calculated cavity radius, and number of detonations, for all detonations, saturated denotations, and unsaturated detonations, in the Yucca Flat basin. Yields in this report are set to either the announced value or the maximum of the announced yield range as noted in USDOE (2000b). As noted in USDOE, 2000b, tests with yield identified as "low" have an announced yield of less than 20 kt and the upper end of the yield range (20 kt) is used for this study; tests with yield identified as "intermediate" have an announced yield range of 20 to 200 kt and the upper end of the yield range (200 kt) is used for this study. USDOE (2000b) offers no amplification for the term "slight"; 20 kt is used for this study based on instructions from the DOE Nevada Field Office (Hernandez, 2012 personal communication).

Table 2.2a Summary information for underground nuclear detonations in shafts and tunnels in Yucca Flat/Climax Mine.

YUCCA FLAT/CLIMAX MINE CAU			
Information type	**All detonations**	**Saturated detonations**	**Unsaturated detonations**
Purpose of detonation[a]			
Joint US–UK	16	10	6
Plowshare	19	4	15
Safety Experiment	64	3	61
Weapons Effects	14	2	12
Weapons Related	634	151	483
WP HSU[b]			
AA	415	28	387
TMUVTA	17	5	12
UTCU	2		2
TMWTA	27	7	20
TMLVTA	128	32	96
LTCU	111	69	42
OSBCU	39	25	14
ATCU	1	1	
MGCU	3	2	1
LCA3	1		1
LCA	3	1	2
Announced yield[c] (kt)			
Average	52	137	27
Minimum value	0	0	0
Maximum value	500	500	200
Calculated cavity radius[d] (m)			
Average	45	58	41
Minimum value	0	0	0
Maximum value	87	87	83
Number of detonations	747	170	577

[a]USDOE, 2000b
[b]See Table 1.2
[c]Announced yield is from USDOE, 2000b. Yields in this report are set to either the announced value or the maximum of the announced yield range. Tests with yield identified as “slight” and “low” are set to 20 kt; “intermediate” is set to 200 kt.
[d]Cavity radius is calculated from the equation [70.2 * yield (kt)$^{1/3}$] / [overburden density (Mg/m^3) * WP depth (m)]$^{1/4}$, from Pawloski, 1999, with the yield defined by footnote c above.

Table 2.2b Summary information for underground nuclear detonations in shafts and tunnels in Area 1.

AREA 1			
Information type	**All detonations**	**Saturated detonations**	**Unsaturated detonations**
Purpose of detonation			
Joint US–UK			
Plowshare			
Safety Experiment	2		2
Weapons Effects			
Weapons Related	2		2
WP HSU			
AA	4		4
TMUVTA			
UTCU			
TMWTA			
TMLVTA			
LTCU			
OSBCU			
ATCU			
MGCU			
LCA3			
LCA			
Announced yield (kt)			
Average	20		20
Minimum value	20		20
Maximum value	20		20
Calculated cavity radius (m)			
Average	38		38
Minimum value	37		37
Maximum value	39		39
Number of detonations	4		4

Table 2.2c Summary information for underground nuclear detonations in shafts and tunnels in Area 2.

AREA 2			
Information type	**All detonations**	**Saturated detonations**	**Unsaturated detonations**
Purpose of detonation			
Joint US–UK	4	4	
Plowshare	9	3	6
Safety Experiment	4		4
Weapons Effects	5		5
Weapons Related	140	33	107
WP HSU			
AA	109	10	99
TMUVTA	2	2	
UTCU			
TMWTA	6	4	2
TMLVTA	33	14	19
LTCU	11	10	1
OSBCU			
ATCU			
MGCU			
LCA3	1		1
LCA			
Announced yield (kt)			
Average	68	146	43
Minimum value	.035	1.07	.035
Maximum value	250	250	200
Calculated cavity radius (m)			
Average	47	60	43
Minimum value	5	13	5
Maximum value	83	75	83
Number of detonations	162	40	122

Table 2.2d Summary information for underground nuclear detonations in shafts and tunnels in Area 3.

AREA 3			
Information type	**All detonations**	**Saturated detonations**	**Unsaturated detonations**
Purpose of detonation			
Joint US–UK	5	1	4
Plowshare			
Safety Experiment	41		41
Weapons Effects	4		4
Weapons Related	224	39	185
WP HSU			
AA	204	15	189
TMUVTA	12	2	10
UTCU	2		2
TMWTA	14	2	12
TMLVTA	17	5	12
LTCU	22	14	8
OSBCU	3	2	1
ATCU			
MGCU			
LCA3			
LCA			
Announced yield (kt)			
Average	32	103	20
Minimum value	0	20	0
Maximum value	249	249	150
Calculated cavity radius (m)			
Average	41	52	39
Minimum value	0	32	0
Maximum value	76	76	71
Number of detonations	274	40	234

Table 2.2e Summary information for underground nuclear detonations in shafts and tunnels in Area 4.

AREA 4			
Information type	**All detonations**	**Saturated detonations**	**Unsaturated detonations**
Purpose of detonation			
Joint US–UK	2	2	
Plowshare			
Safety Experiment	3	3	
Weapons Effects			
Weapons Related	34	24	10
WP HSU			
AA	5	3	2
TMUVTA	2	1	1
UTCU			
TMWTA	2	1	1
TMLVTA	10	5	5
LTCU	17	16	1
OSBCU	3	3	
ATCU			
MGCU			
LCA3			
LCA			
Announced yield (kt)			
Average	102	130	20
Minimum value	0	0	20
Maximum value	500	500	20
Calculated cavity radius (m)			
Average	51	56	38
Minimum value	0	0	36
Maximum value	87	87	41
Number of detonations	39	29	10

Table 2.2f Summary information for underground nuclear detonations in shafts and tunnels in Area 6.

AREA 6			
Information type	**All detonations**	**Saturated detonations**	**Unsaturated detonations**
Purpose of detonation			
Joint US–UK			
Plowshare			
Safety Experiment			
Weapons Effects			
Weapons Related	6		6
WP HSU			
AA	4		4
TMUVTA			
UTCU			
TMWTA			
TMLVTA			
LTCU			
OSBCU			
ATCU			
MGCU			
LCA3			
LCA			
Announced yield (kt)			
Average	20		20
Minimum value	20		20
Maximum value	20		20
Calculated cavity radius (m)			
Average	39		39
Minimum value	36		36
Maximum value	47		47
Number of detonations	6		6

Table 2.2g Summary information for underground nuclear detonations in shafts and tunnels in Area 7**.**

AREA 7			
Information type	**All detonations**	**Saturated detonations**	**Unsaturated detonations**
Purpose of detonation			
Joint US–UK	4	3	1
Plowshare			
Safety Experiment			
Weapons Effects			
Weapons Related	58	44	14
WP HSU			
AA	1		1
TMUVTA	1		
UTCU			
TMWTA			
TMLVTA	1		1
LTCU	36	26	10
OSBCU	22	19	3
ATCU			
MGCU			
LCA3			
LCA	1	1	
Announced yield (kt)			
Average	129	159	32
Minimum value	20	20	20
Maximum value	200	200	200
Calculated cavity radius (m)			
Average	57	63	39
Minimum value	31	31	34
Maximum value	73	73	72
Number of detonations.	62	47	15

Table 2.2h Summary information for underground nuclear detonations in shafts and tunnels in Area 8.

AREA 8			
Information type	**All detonations**	**Saturated detonations**	**Unsaturated detonations**
Purpose of detonation			
Joint US–UK			
Plowshare			
Safety Experiment	2		2
Weapons Effects	1		1
Weapons Related	9		9
WP HSU			
AA	1		1
TMUVTA			
UTCU			
TMWTA			
TMLVTA	4		4
LTCU	1		1
OSBCU	6		6
ATCU			
MGCU			
LCA3			
LCA			
Announced yield (kt)			
Average	40		40
Minimum value	8.7		8.7
Maximum value	150		150
Calculated cavity radius (m)			
Average	41		41
Minimum value	29		29
Maximum value	66		66
Number of detonations	12		12

Table 2.2i Summary information for underground nuclear detonations in shafts and tunnels in Area 9.

AREA 9			
Information type	**All detonations**	**Saturated detonations**	**Unsaturated detonations**
Purpose of detonation			
Joint US–UK	1		1
Plowshare	5		5
Safety Experiment	8		8
Weapons Effects			
Weapons Related	104	5	9
WP HSU			
AA	48		48
TMUVTA			
UTCU			
TMWTA	5		5
TMLVTA	48	4	44
LTCU	15	1	14
OSBCU	2		2
ATCU			
MGCU			
LCA3			
LCA			
Announced yield (kt)			
Average	30	183	23
Minimum value	0.37	115	0.37
Maximum value	200	200	200
Calculated cavity radius (m)			
Average	42	69	41
Minimum value	12	59	12
Maximum value	81	73	81
Number of detonations	118	5	113

Table 2.2j Summary information for underground nuclear detonations in shafts and tunnels in Area 10.

AREA 10			
Information type	**All detonations**	**Saturated detonations**	**Unsaturated detonations**
Purpose of detonation			
Joint US–UK			
Plowshare	5	1	4
Safety Experiment	4		4
Weapons Effects	1		1
Weapons Related	57	6	51
WP HSU			
AA	39		39
TMUVTA			
UTCU			
TMWTA			
TMLVTA	13	3	10
LTCU	9	2	7
OSBCU	3	1	2
ATCU	1	1	
MGCU			
LCA3			
LCA	2		2
Announced yield (kt)			
Average	47	156	34
Minimum value	2.2	20	2.2
Maximum value	200	200	200
Calculated cavity radius (m)			
Average	44	62	42
Minimum value	20	34	20
Maximum value	76	72	76
Number of detonations	67	7	60

Table 2.2k Summary information for underground nuclear detonations in shafts and tunnels in Area 15.

AREA 15			
Information type	**All detonations**	**Saturated detonations**	**Unsaturated detonations**
Purpose of detonation			
Joint US–UK			
Plowshare			
Safety Experiment			
Weapons Effects	3	2	1
Weapons Related			
WP HSU			
AA			
TMUVTA			
UTCU			
TMWTA			
TMLVTA			
LTCU			
OSBCU			
ATCU			
MGCU	3	2	1
LCA3			
LCA			
Announced yield (kt)			
Average	29	34	20
Minimum value	5.7	5.7	20
Maximum value	62	62	20
Calculated cavity radius (m)			
Average	41	37	48
Minimum value	25	25	48
Maximum value	49	49	48
Number of detonations	3	2	1

2.2 Detonations by Year

Detonations sorted by areas, binned into 5-year periods, are shown in Figure 2.3. More detonations occurred earlier in the testing period and fewer later, with a gradual increase in frequency and then a steep decline after 1975. One quarter of the detonations were conducted within the first nine years of underground testing, and just over one-half of the detonations were conducted by the end of 1970 (including all three detonations in Climax Mine), which was within 14 years of the start of testing. About 90% of all detonations were conducted by 1985.

In the Yucca Flat/Climax Min CAU, LANL began underground nuclear testing in Area 3 and then expanded to Area 7. LLNL began testing in Areas 2, 9, and 10. Locating a site was typically based on the requirements of the test emplaced in a specific shaft. Also considered were ease of operations, minimization of shock wave interactions between other planned detonations, and availability of shaft locations.

AREA, YEAR, AND YIELD DETONATION DATA

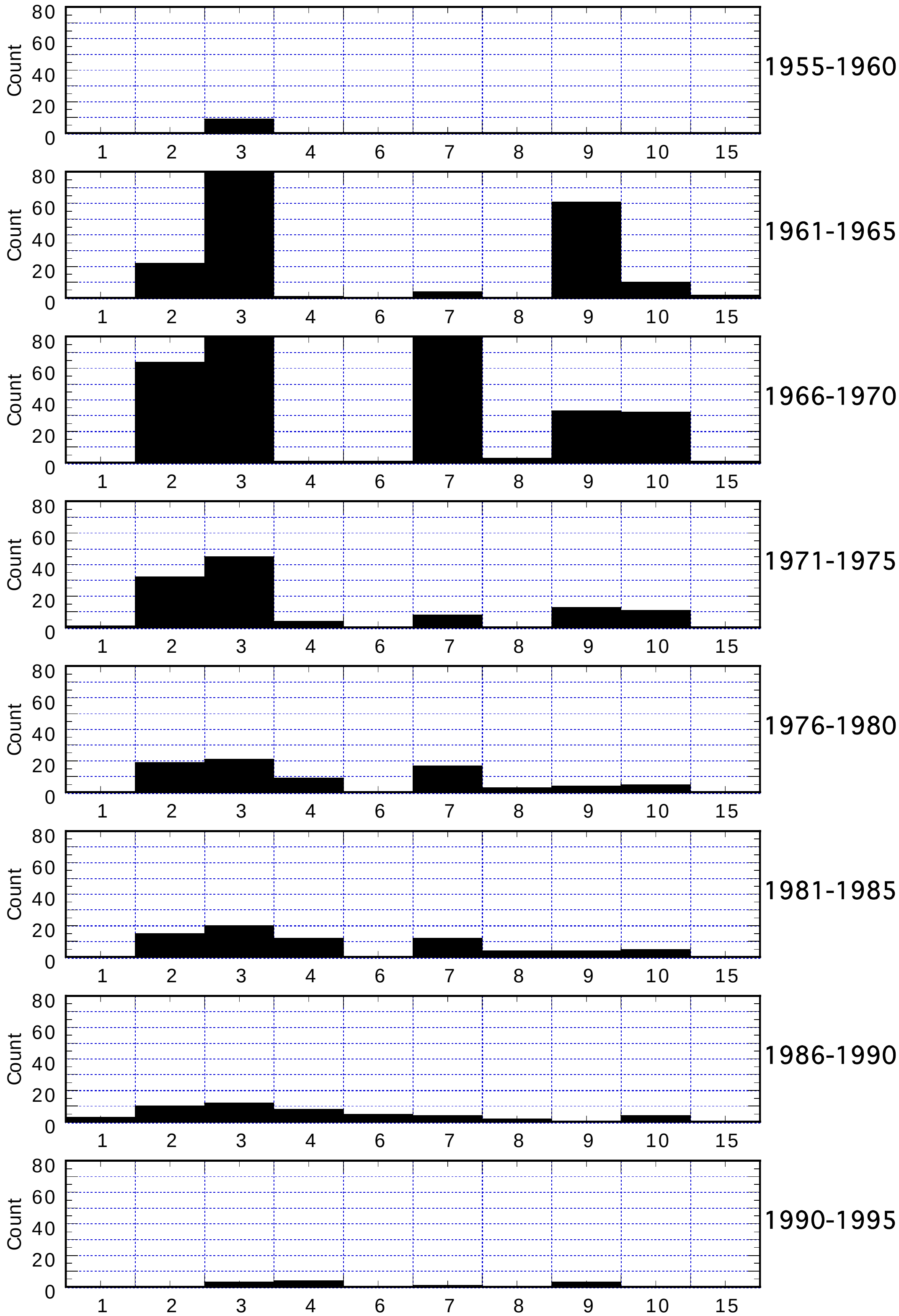

Figure 2.3 Number of underground detonations in shafts and tunnels in Yucca Flat and Climax Mine within each NTS area, starting in 1957 and shown in 5-year intervals.

2.3 Detonations by Yield

Table 2.3 summarizes cumulative numbers of underground detonations in shafts and tunnels and cumulative maximum announced yields, sorted by NTS areas. Seven hundred forty-seven detonations contributed a maximum of 39,051 kilotons (kt) of yield over the 36 years of underground nuclear testing in the Yucca Flat/Climax Mine CAU. In terms of maximum announced yield, about one-half of the total yield in the Yucca Flat/Climax Mine CAU was expended by 1970, and a little over 90% by 1985.

Table 2.3 Cumulative yields (in kt) of detonations, by years and NTS areas, for the Yucca Flat/Climax Mine CAU.

Cumulative number of detonations	Years	Area 1	Area 2	Area 3	Area 4	Area 6	Area 7	Area 8	Area 9	Area 10	Area 15	Cumulative yield for Yucca Flat/Climax Mine CAU
9 (1%)	1955-1960			60								60 (0.2%)
190 (25%)	1961-1965		556	2,295	20		440		1,871	756	26	6,025 (15%)
424 (57%)	1966-1970		4,510	2,696	200	20	2,660	41	1,163	1,870	62	19,246 (49%)
538 (72%)	1971-1975	20	2,568	1,260	440		1,240		260	220		25,254 (65%)
616 (82%)	1976-1980		1,661	680	1,280		2,000	60	80	100		31,115 (80%)
688 (92%)	1981-1985		699	1,050	1,399		1,138	340	80	100		35,912 (92%)
737 (99%)	1986-1990	60	980	500	559	100	470	40		80		38,701 (99%)
747 (100%)	1991-1995			190	80		20		60			39,051 (100%)

2.3.1 Analysis of Detonation Data Sorted by Area

Table 2.4, sorted by NTS area, relates yield range, number of saturated detonations, and WP depth range, with WP in given HSU, over 5-year timeframes. Area 3 hosted the most detonations (36.7%), followed, in order by Area 2 (21.7%), Area 9 (15.8%), Area 10 (9.0%), Area 7 (8.3%), Area 4 (5.2%), Area 8 (1.6%), Area 6 (0.8%), Area 1 (0.5%), and Area 15 (0.3%). About 60% of all detonations in the Yucca Flat/Climax Mine CAU were conducted in Areas 2 and 3.

Area 1 detonations occurred in the time frames of 1971 to 1975 and 1986 to 1990. Area 2 detonations occurred from 1961 to 1990. Area 3 detonations occurred from 1957 to 1992. Areas 4 and 7 detonations occurred from 1961 to 1992. Area 6 detonations occurred from 1966 to 1970 and 1986 to 1990. Area 8 detonations occurred from 1966 to 1970 and 1976 to 1990. Area 9 was used from 1961 through 1992, but not during 1986 to 1990. Area 10 detonations occurred from 1961 to 1990. Climax Mine detonations in Area 15 occurred in 1962, 1965, and 1966.

All WPs for detonations in Area 1 were located in the AA. By far most WPs for detonations in Areas 2, 3 and 10 were located in the AA. WPs for detonations in Area 4 were located in the LTCU and the TM-LVTA. WPs for detonations in Area 6 were conducted in the AA and the TM-LVTA. Most WPs for detonations in Area 7 were conducted in tuff confining units (LTCU and OSBCU). Most WPs for detonations in Area 8 were conducted in a tuff confining unit (LTCU and OSBCU) and the TM-LVTA. Most WPs for detonations in Area 9 were evenly split between the AA and the TM-LVTA. All three WPs in Area 15 were in the MGCU.

Table 2.4 Selected data for underground detonations in shafts and tunnels in the Yucca Flat/Climax Mine CAU, sorted by NTS area.

NTS area locations	Years	Yield range (kt), maximum announced yield	Number (percent) of saturated detonations	WP depth range (m)	WP in AA	WP in TM-UVTA	WP in TM-WTA	WP in TM-LVTA	WP in UTCU	WP in LTCU	WP in OSBCU	WP in ATCU	WP in MGCU	WP in LCA3	WP in LCA	Total number of detonations
1	1971-1990	20	0/4 (0%)	178-258	4											4
2	1962-1990	0.035-250	40/162 (25%)	60-745	109	2	6	33		11				1		162
3	1957-1992	0-249	40/274 (15%)	58-750	204	12	14	17	2	22	3					274
4	1964-1991	0-500	29/39 (74%)	207-782	5	2	2	10		17	3					39
6	1968-1990	20	0/6 (0%)	120-351	4			2								6
7	1964-1991	20-200	47/62 (76%)	198-701	1	1		1		36	22				1	62
8	1966-1988	8.7-150	0/12 (0%)	200-515	1			4		1	6					12
9	1961-1992	0.37-200	5/118 (4%)	58-582	48		5	48		15	2					118
10	1962-1987	2.2-200	7/67 (10%)	91-679	39			13		9	3	1			2	67
15	1962-1966	5.7-62	2/3 (67%)	111-463									3			3
					415	17	27	128	2	111	39	1	3	1	3	747

2.3.2 Analysis of Detonation Data Sorted by Year

Table 2.5, sorted by 5-year time periods, relates NTS area, yield range, percent of saturated detonations, and WP depth range, with WP in a given HSU. More details on HSUs are provided in Chapter 4. As also shown in Figure 2.3, testing first occurred in Area 3, and was then generally spread over all areas. More detonations occurred earlier in testing, and fewer later, with a gradual increase in frequency and then a steep decline after 1975. During the 5-year time periods examined, 1966-1970 held the most detonations (234). From 1961 to 1970, 415 detonations were held. About one half of the detonations at the NTS had been conducted by the end of 1970 (including all three detonations in Climax Mine). About 90% of the detonations were conducted by 1985.

Saturated detonations began in the 1961-1965 time frame and increased over time. Between 35 and 45 percent of the detonations conducted from 1976 to 1992 were considered to be saturated detonations.

Through 1980, most WPs were located in the AA. After 1980, less than one half of the detonations in a given time frame were located in the AA; most were located in vitric tuffs (TM-UVTA and TM-LVTA) and confining units (UTCU, LTCU, OSBCU, ATCU, and MGCU). Three detonations located in the carbonate aquifer occurred in 1962, 1965, and 1966.

Table 2.5 Selected data for underground detonations in shafts and tunnels in the Yucca Flat/Climax Mine CAU, sorted by yield ranges.

Dates	NTS area locations	Yield range (kt) maximum announced yield	Number (percent) of saturated detonations	WP depth range (m)	WP in AA	WP in TM-UVTA	WP in TM-WTA	WP in TM-LVTA	WP in UTCU	WP in LTCU	WP in OSBCU	WP in ATCU	WP in MGCU	WP in LCA3	WP in LCA	Total number of detonations
1957-1960	3	0-20	0/9 (0%)	71-152	9											9
1961-1965	2,3,4,7,9,10,15	0-240	21/181 (12%)	58-750	132	1	6	22		15	2		2		1	181
1966-1970	2,3,4,6,7,8,9,10,15	0.035-250	44/234 (19%)	88-745	129	1	11	48	1	29	10	1	1	1	2	234
1971-1975	1,2,3,4,7,9,10	15-200	26/114 (23%)	120-716	71	3	2	20		14	4					114
1976-1980	2,3,4,7,8,9,10	0-500	32/78 (41%)	183-782	38		2	9		20	9					78
1981-1985	2,3,4,7,8,9,10	20-150	26/72 (36%)	183-640	16	9	1	19	1	19	7					72
1986-1990	1,2,3,4,6,7,8,10	20-150	17/48 (35%)	183-640	19	3	4	10		8	4					48
1991-1992	3,4,7,9	20-150	5/11 (45%)	244-503	1		1			6	3					11
					415	17	27	128	2	111	39	1	3	1	3	747

2.3.3 Analysis of Detonation Data Sorted by Yield Ranges

Three detonations had zero yield: SAN JUAN, a safety experiment in Area 3 in 1958; COURSER in Area 3 in 1964; and TRANSOM, emplaced in Area 4 in 1978. The TRANSOM device was destroyed by the HEARTS detonation on September 6, 1979. SAN JUAN had a shallow WP (71 m); COURSER had a WP depth of 359 m, and the WP depth for TRANSOM was 640 m.

Seventy-seven percent of the detonations had a yield range of <20 kt and were conducted in all areas of the Yucca Flat/Climax Mine CAU. These detonations were conducted over the entire timeframe (1957-1992). Although the WP range of the detonations is wide (58-688 m), few (6%) of these detonations were saturated. Most of the WPs were located in the alluvial aquifer; one detonation was located in the carbonate aquifer.

About 11% of the detonations had yields in the range of greater than 20 but less than or equal to150 kt. These detonations were conducted between 1962 and 1991, in all areas but Area 6. The WP range of these detonations was deeper than those above, from 207 to701 m. Most of these WPs were located in the LTCU, and 84% of the detonations were saturated.

About 11% of the detonations had a yield greater than 150 kt. These detonations were conducted between 1962 and 1991, in all areas but 6, 8, and 15. The WP range of these detonations was the deepest of these yield categories, from 274 to 782 m. Like the group above, these detonations were mainly located in the lower tuff confining unit; two were located in the carbonate aquifer. Seventy-four percent of these detonations were saturated.

In general, lower-yield detonations were located in all areas of the Yucca Flat/ Climax Mine CAU, had shallower WPs, were unsaturated, and were mainly located in the alluvial aquifer. Larger-yield detonations had deeper WPs, were saturated, and were located in deeper units, namely the tuff confining units.

3.0 Analysis of Detonation Data by Hydrostratigraphic Unit

3.1 Setting the Stage

Previous attempts at categorizing tests on Pahute Mesa (Pawloski et al., 2002) concluded that utilizing stratigraphy or physical properties, at the scale of an emplacement hole, was, at best inconclusive, and at worst, not useful at all for identifying categories of tests for radionuclide migration modeling. Stratigraphic naming of units relies on petrology (mineralogy, lithology, and provenance), which provides insufficient unique information to differentiate various units that may be chemically or lithologically similar. This is especially true for layered volcanic units with large horizontal and vertical extents in the southwestern Nevada volcanic field. Physical property data acquired by the Containment Programs at LANL and LLNL (such as bulk density, grain density, velocity, etc.) correlate to lithology (bedded tuff and welded tuff, for example), but similar properties can cross stratigraphic boundaries. The UGTA Project has focused on defining and utilizing HSUs based on stratigraphy, lithology, and the rocks' ability to transmit groundwater (see Table 1.2). A study of the TCU in Yucca Flat determined that alteration minerals, important for sorption of radionuclides (thus reducing transport) can also be used to subdivide HSUs (Prothro, 2005).

The volume of material defined by the 2-cavity radii (2-Rc) both above and below the WP (4-cavity radii total) usually captures the initial distribution of radionuclides and typically encompasses the rock material that is mechanically altered and thus has modified hydraulic properties (Pawloski, 1999). This region seems sufficient to represent the initial volume of the radionuclide inventory at time zero for source term models. Investigation of these 2-Rc volumes is the focus of this chapter.

3.2 Analysis of HSU Data

Appendix B shows HSU information for the 2-Rc for all detonations in the Yucca Flat/Climax Mine CAU, and relates WP and water table. The table is sorted by values calculated using the WP depth minus the water table depth. In general, detonations with shallower WPs, farther from the water table, are earlier in this table, while detonations deeper below that water table are at the end. Saturated detonations are those with a WP depth minus water table depth of -100 m or greater. Only about one quarter of the detonations meet this definition—170 detonations (23%). Seventy-seven percent of the detonations (577 of 747) occurred with the WP in an unsaturated environment.

Hydrostratigraphic data in Appendix B were derived from the EarthVision® model (Bechtel Nevada, 2006). Significant effort was applied to qualify the data, since the categorization analysis was concurrent with the construction of the EarthVision® model. It is possible that the finalized model will cause some modifications in HSU assignment, and it may modify conclusions in this report.

A few modifications in WP HSU assignment were made for the categorization project. Since only one detonation was identified with a WP in the playa confining unit (PCU), this assignment was changed to the alluvial aquifer (AA). The change seems reasonable since the PCU occurs stratigraphically within the AA. The Topopah Spring Aquifer (TSA) was considered lithologically similar to the Timber Mountain Welded Tuff Aquifer (TM-WTA). Emplacement holes with TSA at the WP are identified in Appendix B, but the TSA is grouped with the TM-WTA for the analyses presented in this report.

Hydrostratigraphic units were analyzed to determine if categories of detonations could be identified for (1) selected HST modeling and (2) developing ranges of data for all detonations for SST modeling. The process identified the WP depth, WP minus 2-Rc depth (uphole), and WP plus 2-Rc depth (downhole) for all detonations. Cavity radii are calculated from a standard formula using either the announced (absolute) yield or the maximum of the announced yield range of a given detonation. Where the maximum of the yield range is used, the amount of rock within the 2-Rc, both above and below the WP, represents a conservatively large volume for radionuclide transport modeling. HSUs at the WP, minus 2-Rc depth, and plus 2-Rc depth were extrapolated from the EarthVision® model. It was assumed that there were no intervening HSUs within the 2-Rc volumes above and below the WP. It is important to note that HSUs at the minus 2-Rc and at the WP are identified by drill hole penetration data. Because emplacement holes frequently did not extend much deeper than the WP, the HSUs at the plus 2-Rc depth are most likely extrapolated from the EarthVision® model rather than representing drilling penetration data.

Combinations of HSUs at minus 2-Rc/WP/plus 2-Rc volumes were examined to see if common categories could be identified. In the following tables, these HSUs were color coded to provide some visual understanding of the large data set. Similar groups of HSUs were given a family color, and each HSU was assigned a unique color. For example, Timber Mountain HSUs were coded green, with bright green assigned to TM-UVTA, sea green to the TM-WTA, and green to TM-LVTA. Altered tuff units (confining units) were coded to yellow-brown colors, with yellow assigned to the UTCU, gold assigned to the LTCU, light orange to the OSBCU, and orange to the ATCU. Carbonate aquifer rocks were coded blue, with aqua assigned to the LCA3 and light blue assigned to the LCA. No WPs are located in clastic confining units, but these units are included in the tables because the plus 2-Rc region can extend to these depths. Clastic confining units were coded gray, with light gray assigned to the UCCU and dark gray to the LCCU. Table 3.1 provides a summary of color-coded HSUs and counts of detonations in shafts and tunnels per HSU.

Table 3.1 Color-coded HSUs and numbers of WPs in HSUs

	Number of detonations with WP	Number of detonations with saturated WP	Number of detonations with unsaturated WP
AA	415	28	387
TM-UVTA	17	5	12
UTCU	2	0	2
TM-WTA	27	7	20
TM-LVTA	128	32	96
LTCU	111	69	42
OSBCU	39	25	14
ATCU	1	1	0
MGCU	3	2	1
LCA3	1	0	1
LCA	3	1	2
UCCU	0	0	0
LCCU	0	0	0

As noted in Table 3.1, detonations with WPs higher in the stratigraphic column (AA through TM-LVTA) tend to be unsaturated. As noted in Tables 2.4 and 2.5, these detonations had shallower WPs. WPs sited lower in the stratigraphic column (LTCU through ATCU) are deeper and tend to be saturated. This is consistent with the structural setting of Yucca Flat, where, in general, older (lower) stratigraphic units are deeper in the basin.

The following tables (Tables 3.2 to 3.12) show the number of possible combinations of 2-Rc above WP/WP/2-Rc below WP HSUs. WPs are investigated in stratigraphic order, alluvial aquifer first and carbonate aquifer last. Maps (Figures 3.1 to 3.27) show the locations of all detonations for a particular WP HSU, followed by separate maps showing saturated and unsaturated detonations for that WP HSU.

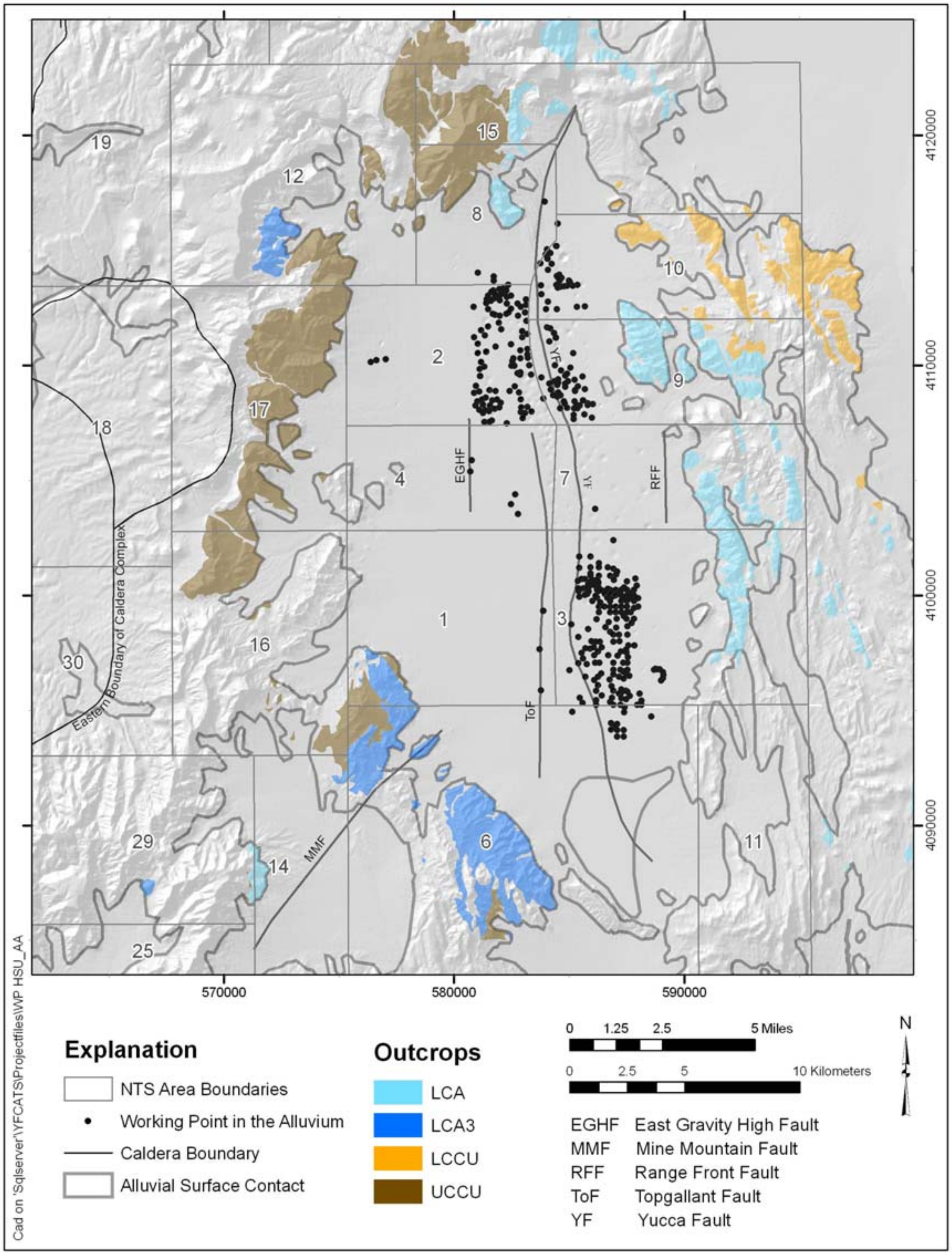

Figure 3.1 Locations of detonations with WP in the AA.

Table 3.2 HSU information for the 2-Rc volumes for detonations with WPs in the AA.

ALL DETONATIONS	minus2Rc	415							
	WP	415							
	plus2Rc	275	31	39	55	8	2	2	3
SATURATED DETONATIONS	minus2Rc	28							
	WP	28							
	plus2Rc	7	7	3	9	2			
UNSATURATED DETONATIONS	minus2Rc	387							
	WP	387							
	plus2Rc	268	24	36	46	6	2	2	3

Legend (HSUs are identified in Table 1.2)

AA
TM-UVTA
UTCU
TM-WTA
TM-LVTA
LTCU
OSBCU
ATCU
MGCU
LCA3
LCA
UCCU
LCCU

Categories of detonations with WP in the AA:

All detonations—8

Saturated detonations—5

Unsaturated detonations——8

Alluvium covers the ground surface of Yucca Flat basin (Bechtel Nevada, 2006). Slightly over half (56%) of the detonations conducted in Yucca Flat had WPs in the AA. In general, these detonations were located in the north-central and south-central parts of the basin, from Area 8 in the north to Area 6 in the south (Figure 3.1). There are very few detonations with WPs in AA in central Yucca Flat and only a few in western Area 2. Most detonations with WPs in the AA were located in western Area 3, east of the Yucca Fault; eastern Area 2, between the Carpetbag and Yucca faults; and western Areas 9 and 10 just east of the Yucca Fault. These are locations where the alluvium is thick due to general basin shape, and also due to tilting of faulted structural blocks. Other detonations with WPs in AA are scattered in Areas 4, 6, 7, and 8.

Saturated detonations with WPs in the AA (Figure 3.2) are essentially a subset of the unsaturated AA detonations (Figure 3.3), and occur in a thin band just east of large faults, where the alluvium is thick due to tilting of faulted structural blocks. Saturated detonations with WPs in the AA are mainly located in Areas 3 and 2, with a few in Area 4.

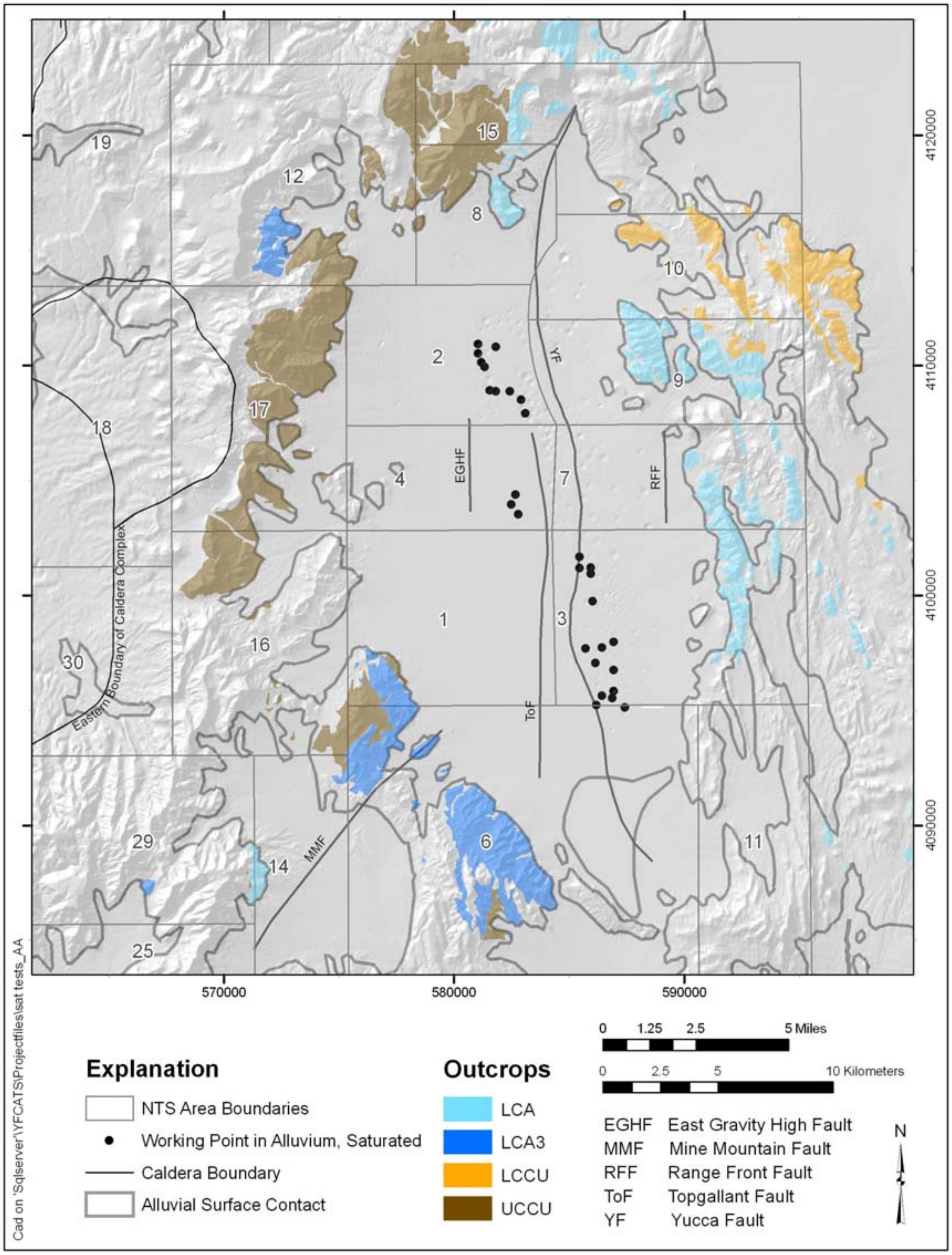

Figure 3.2 Locations of detonations with WPs in the saturated AA.

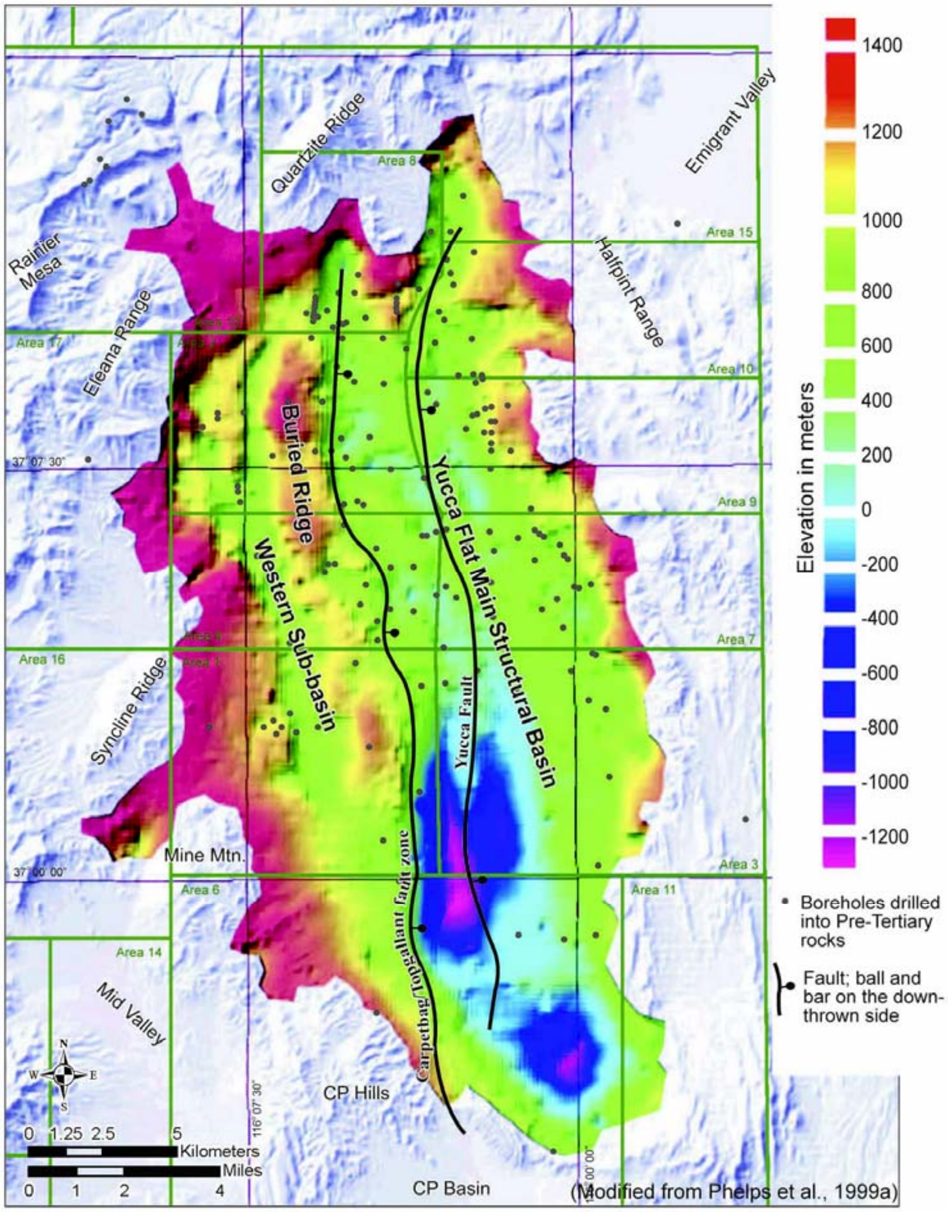

Figure 3.29 Color elevation relief map of the pre-Tertiary surface beneath Yucca Flat based on gravity data (as presented in Bechtel Nevada (2006), modified from Phelps et al., (1999)).

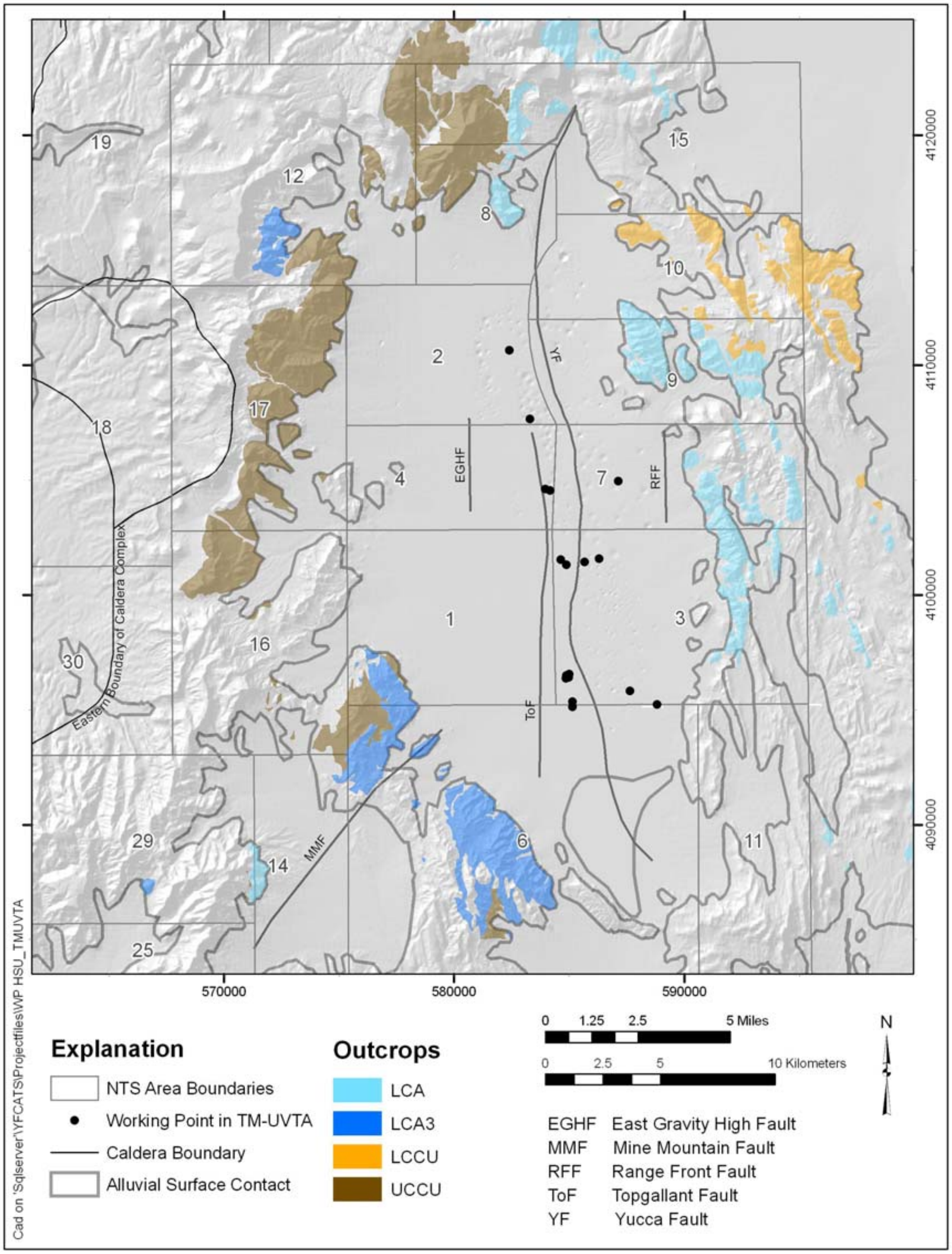

Figure 3.4 Locations of detonations with WPs in the TM-UVTA.

Table 3.3 HSU information for the 2-Rc volumes for detonations with WPs in the TM-UVTA.

ALL DETONATIONS	minus2Rc	16		1
	WP	17		
	plus2Rc	14	2	1
SATURATED DETONATIONS	minus2Rc	4		1
	WP	5		
	plus2Rc	4		1
UNSATURATED DETONATIONS	minus2Rc	12		
	WP	12		
	plus2Rc	10	2	

Legend (HSUs are identified in Table 1.2)

AA
TM-UVTA
UTCU
TM-WTA
TM-LVTA
LTCU
OSBCU
ATCU
MGCU
LCA3
LCA
UCCU
LCCU

Categories of detonations with WPs in the TM-UVTA:

All detonations—3

Saturated detonations—2

Unsaturated detonations—2

A small portion of detonations in Yucca Flat (2%) had WPs in the TM-UVTA. Most are located in western Area 3, while the remainder are sprinkled in eastern Areas 2 and 4 and western Area 7 (Figure 3.4). These detonations are located just east of large-displacement faults (and smaller-displacement faults in Area 3), in thicker depositional sections resulting from tilting of faulted structural blocks. The EarthVision® model (Bechtel Nevada, 2006) shows the TM-UVTA present in central Yucca Flat, with its northernmost extent in east central Area 2. The unit is present in easternmost Areas 1 and 4, and western Areas 3 and 7. The southernmost extent in the Yucca Flat basin is central Area 6, ending near outcrop of LCA3 to the west. A small isolated section of TMcentral Area 6, ending near outcrop of LCA3 to the west. A small isolated section of TM-UVTA straddles western Areas 2 and 4, where a small basin is present west of the East Gravity High Fault. Detonations with WPs in the TM-UVTA are located within the distribution of detonations with WPs in the AA.

Detonations with WPs in the saturated TM-UVTA are located near the surface trace of the Topgallant and Yucca faults (Figure 3.5). At depth, the WPs are located just to the east of the faults, in the deepest portion of the basin fill above the down-dropped and tilted-to-the west section of the normal fault. Unsaturated TM-UVTA detonations tend to be located slightly further to the east (Figure 3.6), where the depositional section is a bit thinner compared to the locations of the saturated detonations.

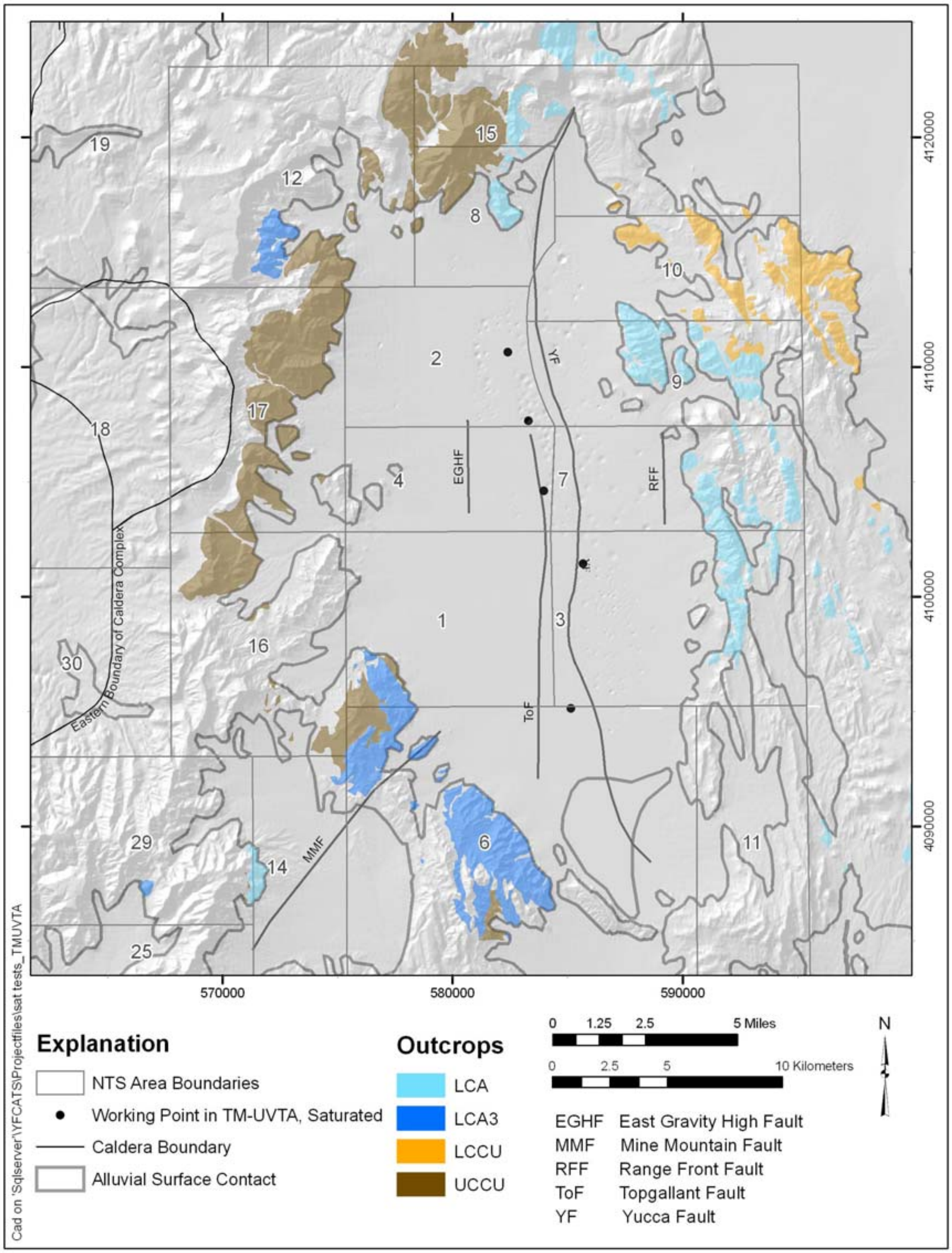

Figure 3.5 Locations of detonations with WPs in the saturated TM-UVTA.

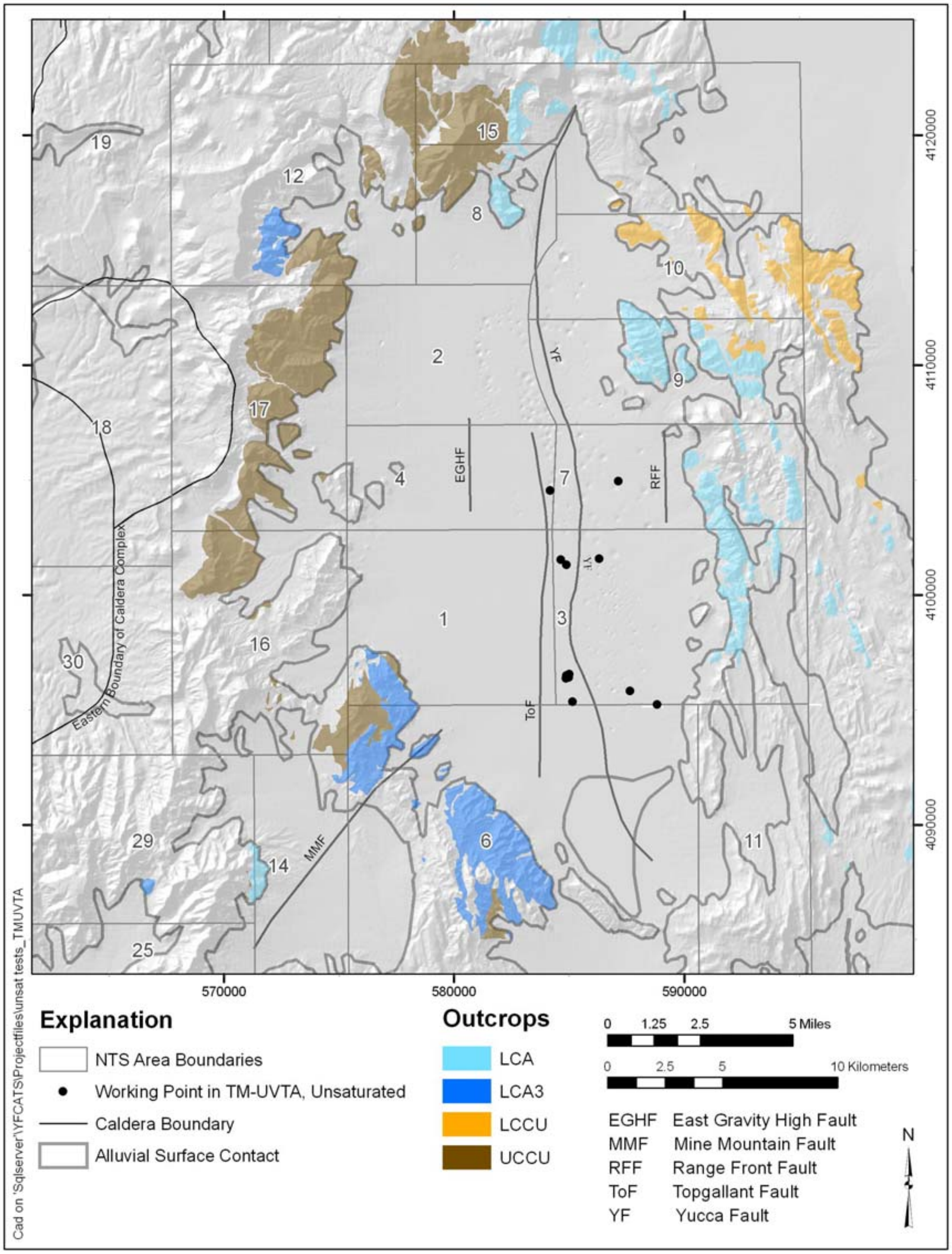

Figure 3.6 Locations of detonations with WP in the unsaturated TM-UVTA.

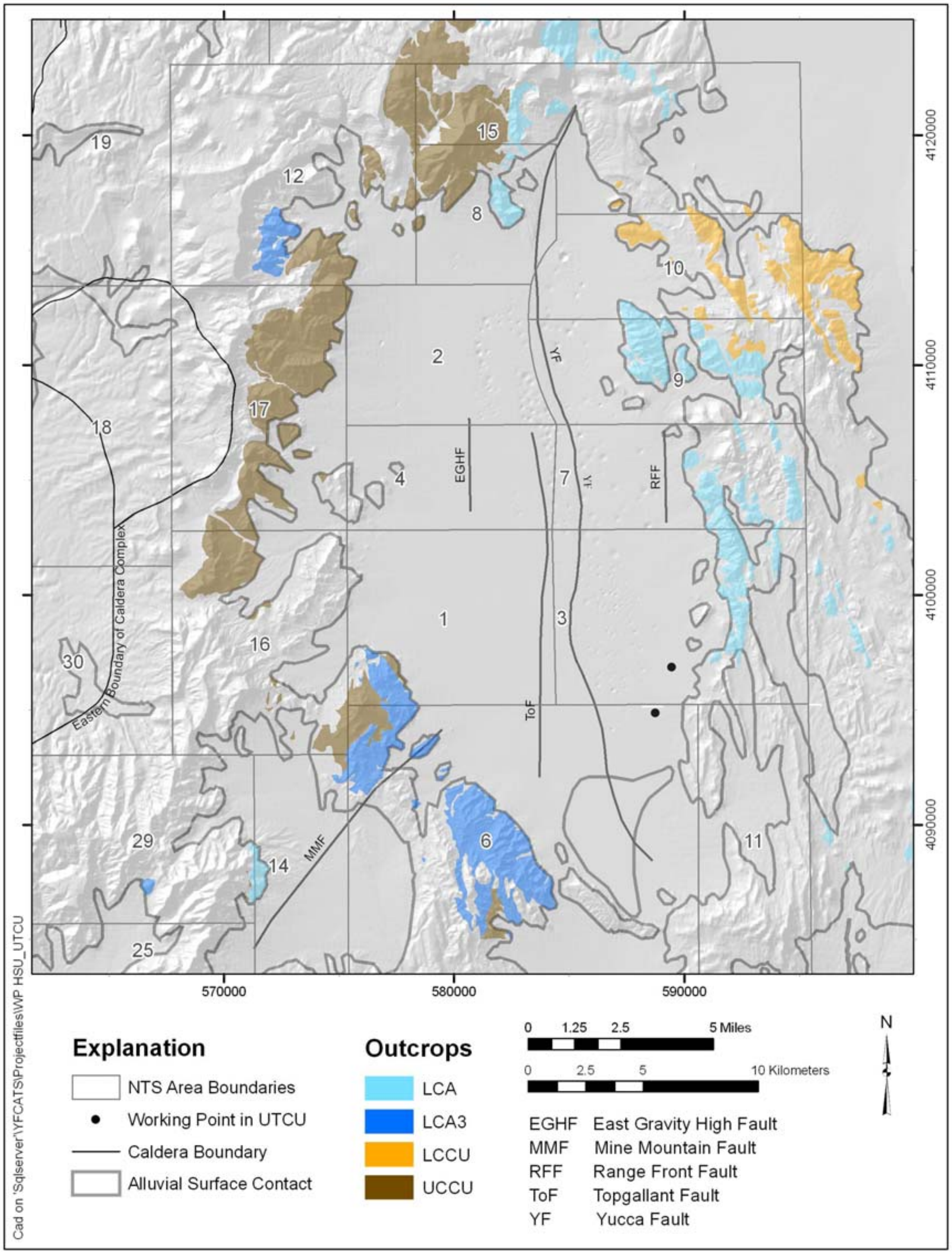

Figure 3.7 Locations of detonations with WP in the UTCU.

Table 3.4 HSU information for the 2-Rc volumes for detonations with WPs in the UTCU.

ALL DETONATIONS	minus2Rc	1	1
	WP	2	
	plus2Rc	2	
SATURATED DETONATIONS	minus2Rc		
	WP		
	plus2Rc		
UNSATURATED DETONATIONS	minus2Rc	1	1
	WP	2	
	plus2Rc	2	

Legend (HSUs are identified in Table 1.2)

AA
TM-UVTA
UTCU
TM-WTA
TM-LVTA
LTCU
OSBCU
ATCU
MGCU
LCA3
LCA
UCCU
LCCU

Categories of detonations with WPs in the UTCU:

All detonations—2

Saturated detonations—0

Unsaturated Detonations—2

Less than 1% of the detonations in Yucca Flat (two detonations total) have WPs in the UTCU, and they are located in south central Area 3 and northeastern Area 6 (Figure 3.7). [Both detonations are considered Area 3 holes (U-3gk and U-3lc).] The EarthVision® model (Bechtel Nevada, 2006) shows UTCU present in southeastern Yucca Flat, with its northernmost extent just crossing the southwestern boundary of Area 3. The UTCU is present only where TSA is present in the model. The two detonations with WPs in the UTCU are located near the eastern edge of Yucca Flat, where the depositional section is thinner than in the central part of Yucca Flat basin.

Both detonations in the UTCU are unsaturated, so no separate saturated and unsaturated maps are shown.

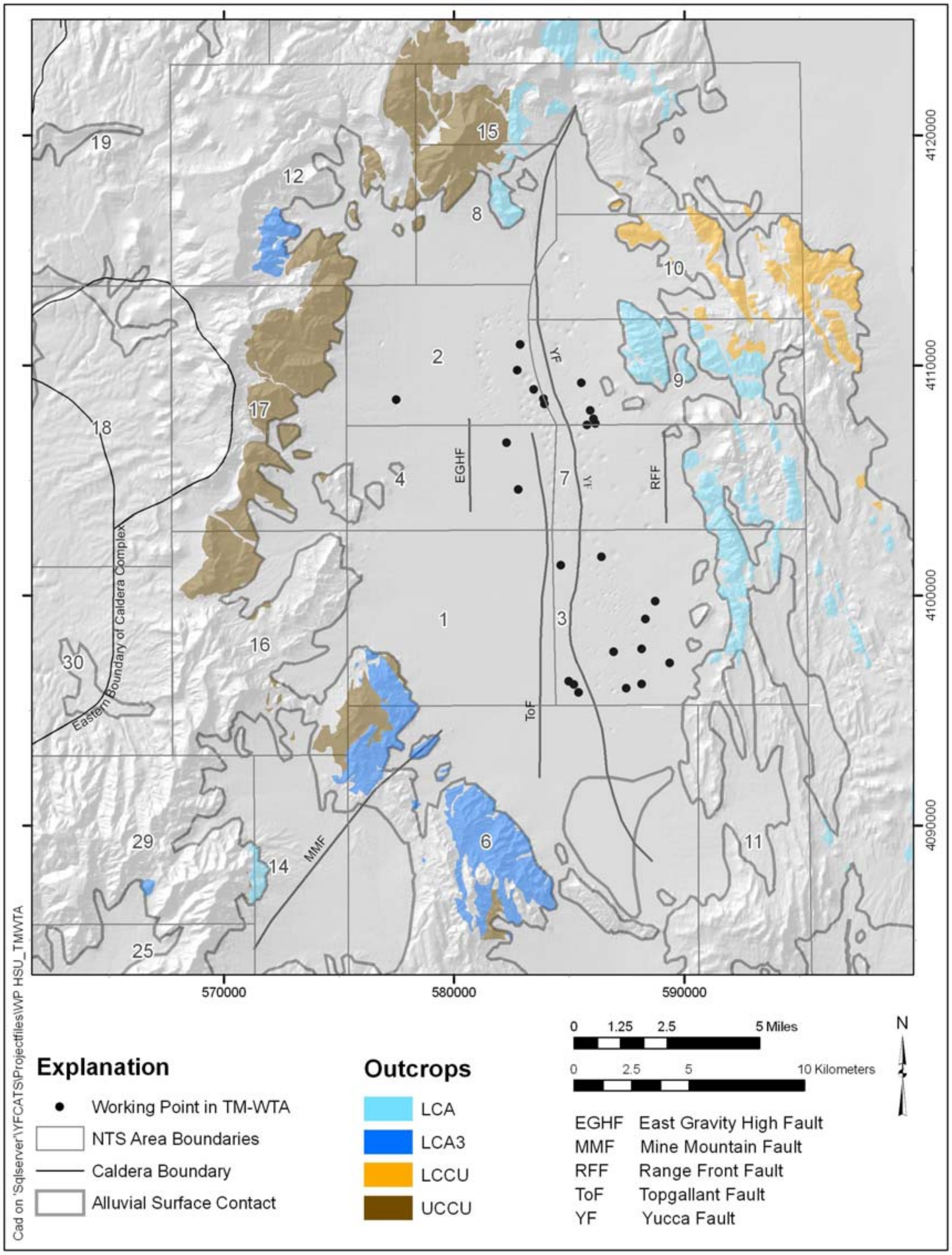

Figure 3.8 Locations of detonations with WPs in the TM-WTA.

Table 3.5 HSU information for the 2-Rc volumes for detonations with WPs in the TM-WTA.

ALL DETONATIONS	minus2Rc	22			3		1	1
	WP	27						
	plus2Rc	2	15	5	1	2	1	1
SATURATED DETONATIONS	minus2Rc	6				1		
	WP	7						
	plus2Rc		4	2		1		
UNSATURATED DETONATIONS	minus2Rc	16			2		1	1
	WP	20						
	plus2Rc	2	11	3	1	1	1	1

Legend (HSUs are identified in Table 1.2)

AA
TM-UVTA
UTCU
TM-WTA
TM-LVTA
LTCU
OSBCU
ATCU
MGCU
LCA3
LCA
UCCU
LCCU

Categories of detonations with WP in the TM-WTA:

All detonations—7

Saturated detonations—3

Unsaturated detonations—7

About 4% of the detonations in Yucca Flat had WPs in the TM-WTA (or the TSA). In order for welded tuffs to form they require a rather thick section, which permits the components to weld together. This usually means that welded tuffs are deposited as large volumes in deeper structural depressions when compared to other volcanic formations.

Detonations with WPs in the TM-WTA are mainly located in north-central and south-central Yucca Flat (Figure 3.8), similar to detonations with WPs in the TM-UVTA. The EarthVision® model (Bechtel Nevada, 2006) shows the TM-WTA present in central Yucca Flat—easternmost Areas 1, 2, and 4, and western Areas 3, 7, and 9. This unit continues into northeastern Area 6 and is deepest in west central Area 3. Detonations unit continues into northeastern Area 6 and is deepest in west central Area 3. Detonations in the TM-WTA are located in the thicker depositional areas on the down-dropped side of faults (the Topgallant and Yucca faults), in eastern Areas 2 and 4, western Area 9, and in Area 3 between the Topgallant and Yucca faults. Additional detonations are located in central Area 3 and western Area 2, near smaller faults.

Saturated detonations with WPs in the TM-WTA are located in eastern Areas 2 and 4, and southwest Area 3 (Figure 3.9). Unsaturated detonations tend to be located slightly further to the east of saturated TM-WTA detonations (Figure 3.10) in the same tilted structural block, where the depositional section is a bit thinner. Another detonation is located in western Area 2, in a small fault-bound basin with thinner accumulations of deposits than the central portion of the Yucca Flat basin.

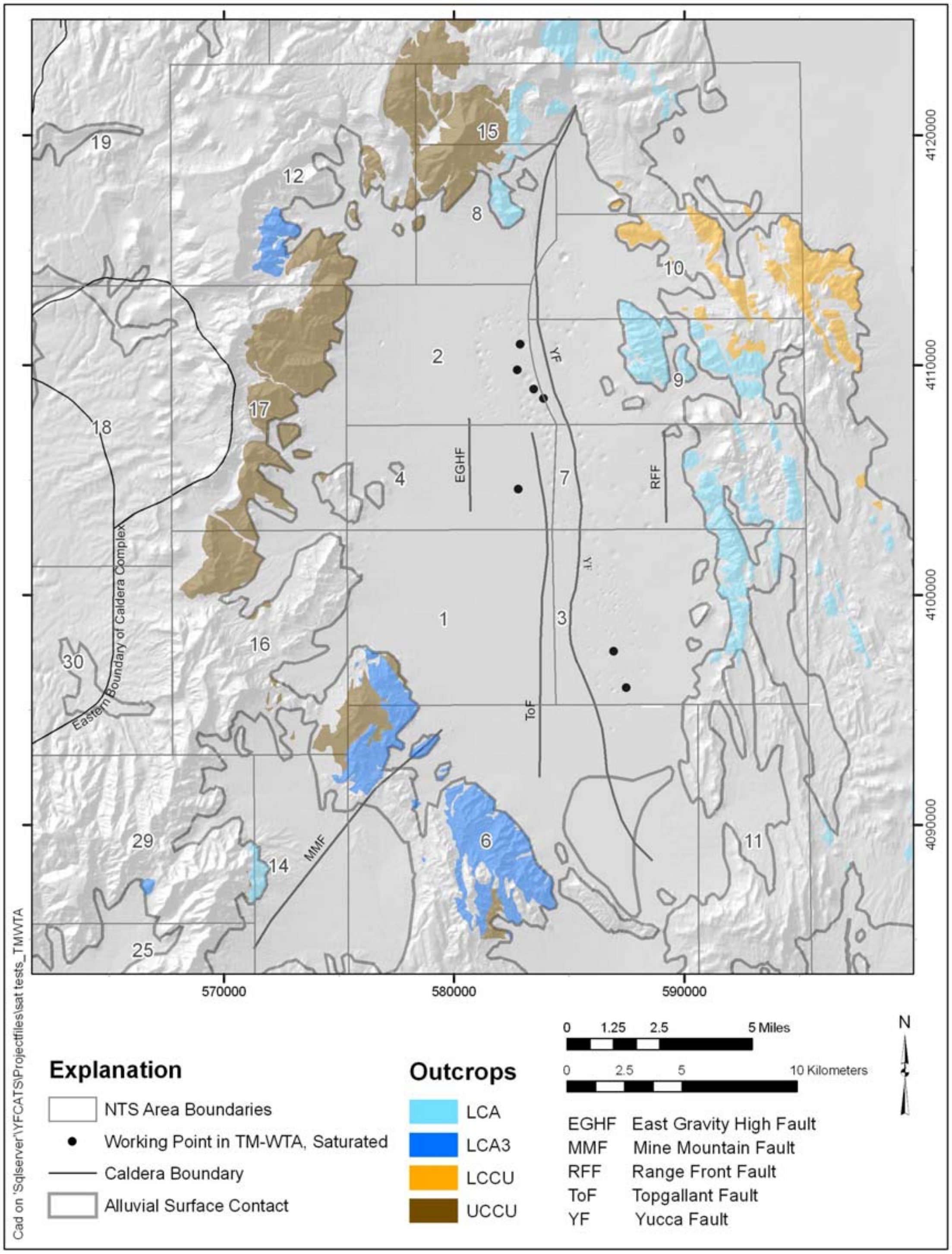

Figure 3.9 Locations of detonations with WPs in the saturated TM-WTA.

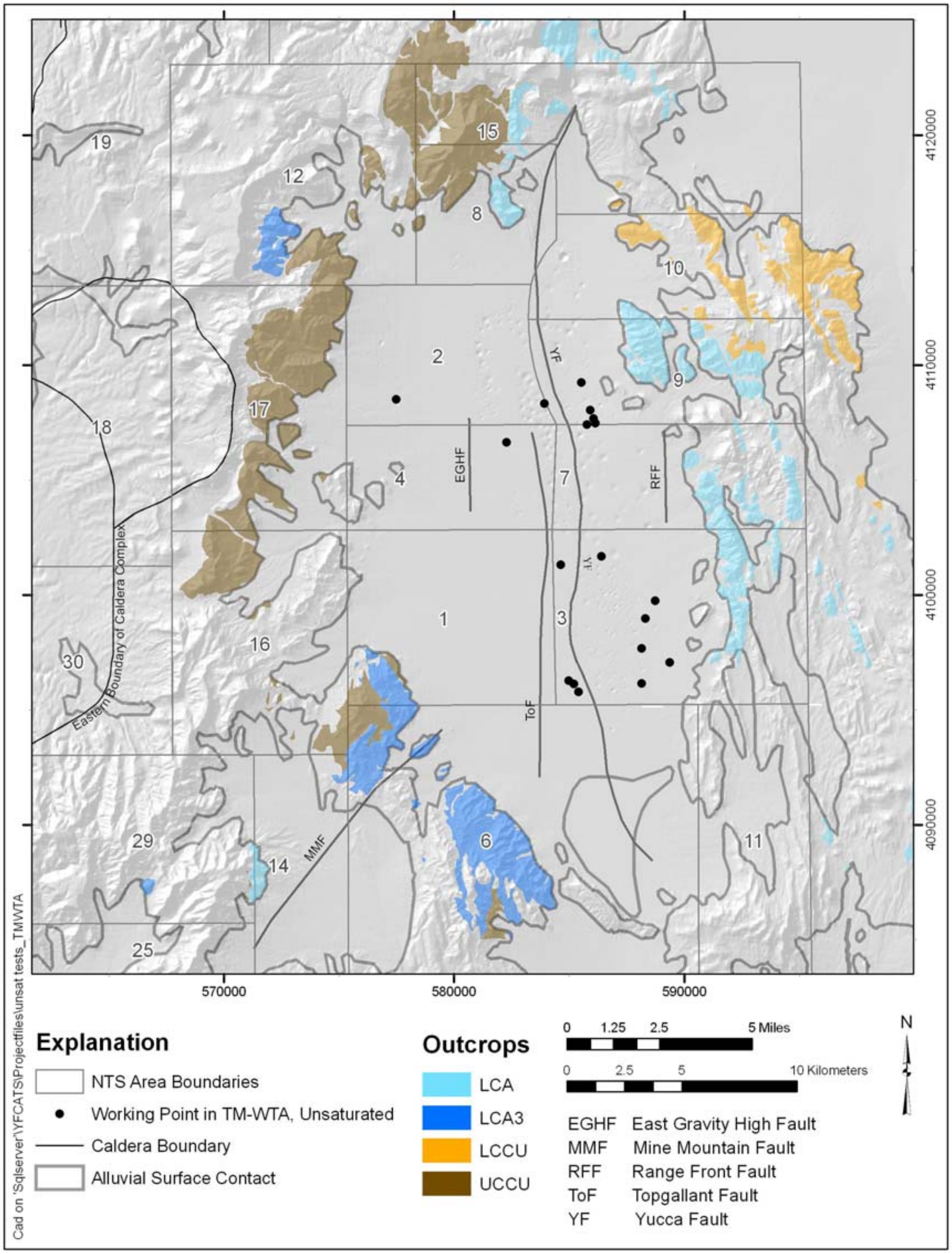

Figure 3.10 Locations detonations with WP in the unsaturated TM-WTA.

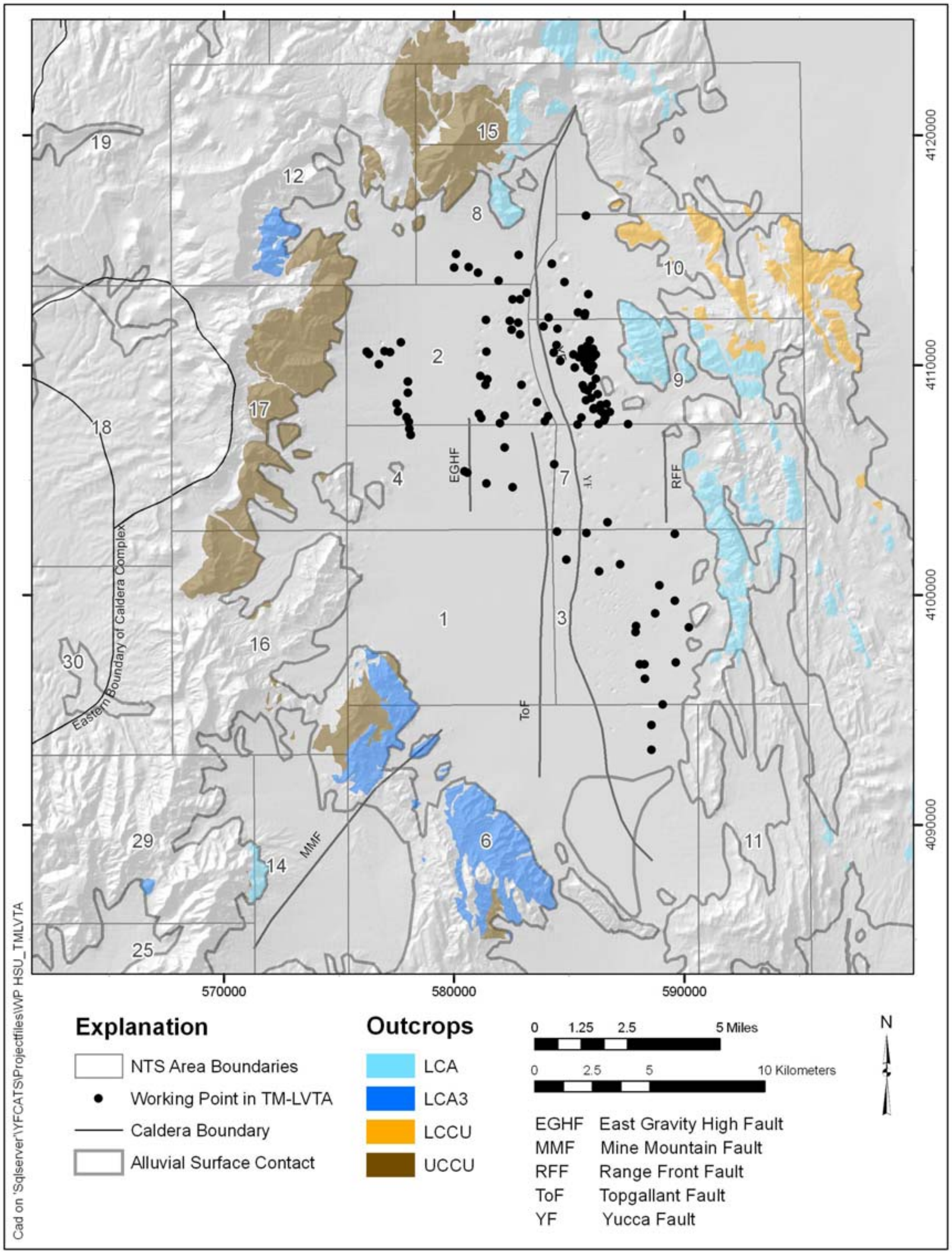

Figure 3.11 Locations of detonations with WPs in the TM-LVTA.

Table 3.6 HSU information for the 2-Rc volumes for detonations with WPs in the TM-LVTA.

ALL DETONATIONS	minus2Rc	56						4	13			54					
	WP	128															
	plus2Rc	1	25	18	5	1	6	4	2	3	9	18	20	2	3	4	7
SATURATED DETONATIONS	minus2Rc	18						3	3			7					
	WP	32															
	plus2Rc		7	7	4			3			4	2	1	2		2	
UNSATURATED DETONATIONS	minus2Rc	38						1	10			47					
	WP	96															
	plus2Rc	1	18	11	1	1	6	1	2	3	5	16	19		3	2	7

Legend (HSUs are identified in Table 1.2)

AA
TM-UVTA
UTCU
TM-WTA
TM-LVTA
LTCU
OSBCU
ATCU
MGCU
LCA3
LCA
UCCU
LCCU

Categories of detonations with WP in the TM-LVTA:

All detonations—16

Saturated detonations—9

Unsaturated detonations—15

Detonations with WPs in the TM-LVTA account for 17% of all detonations in Yucca Flat. This HSU is present over much of the Yucca Flat basin, except near basin edges where depositional sections are thinner and pre-Tertiary units are higher in the stratigraphic section (Bechtel Nevada, 2006). These detonations are sprinkled across northern Yucca Flat and in the east central part of the basin (Figure 3.11). They are located east of larger-displacement faults (Yucca, Topgallant, East Gravity High faults), in the basin in western Areas 2 and 4, and in west central Area 3.

Saturated detonations with WPs in the TM-LVTA (Figure 3.12) are closer to the east side of faults than the unsaturated TM-LVTA detonations (Figure 3.13). Unsaturated detonations are also located in the northern end of the Yucca Flat basin (Areas 8 and 10), and in central Area 3, continuing into northeastern Area 6. These unsaturated detonations are located in thinner sections of basin fill, nearer to the structural edges of the basin.

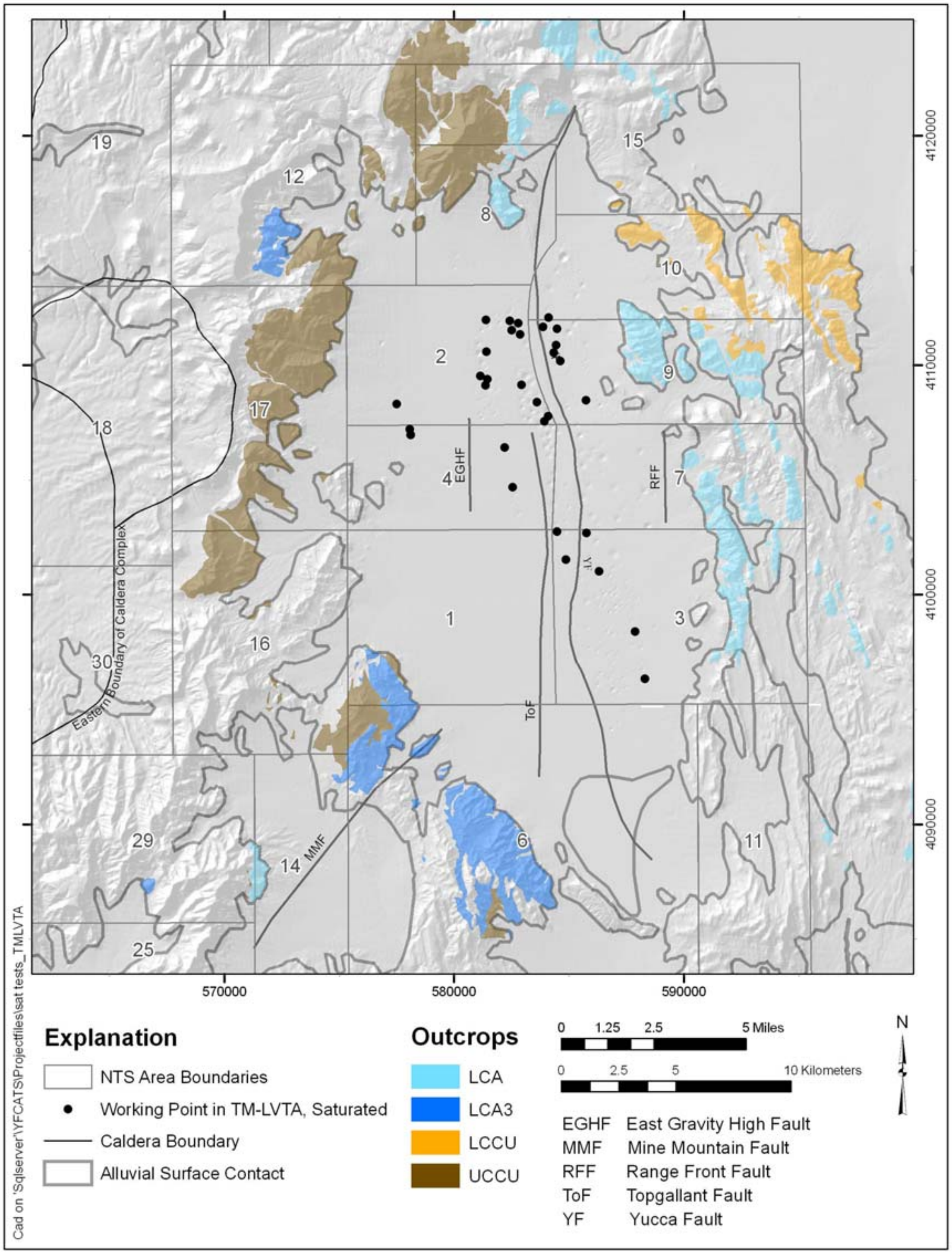

Figure 3.12 Locations of detonations with WP in the saturated TM-LVTA.

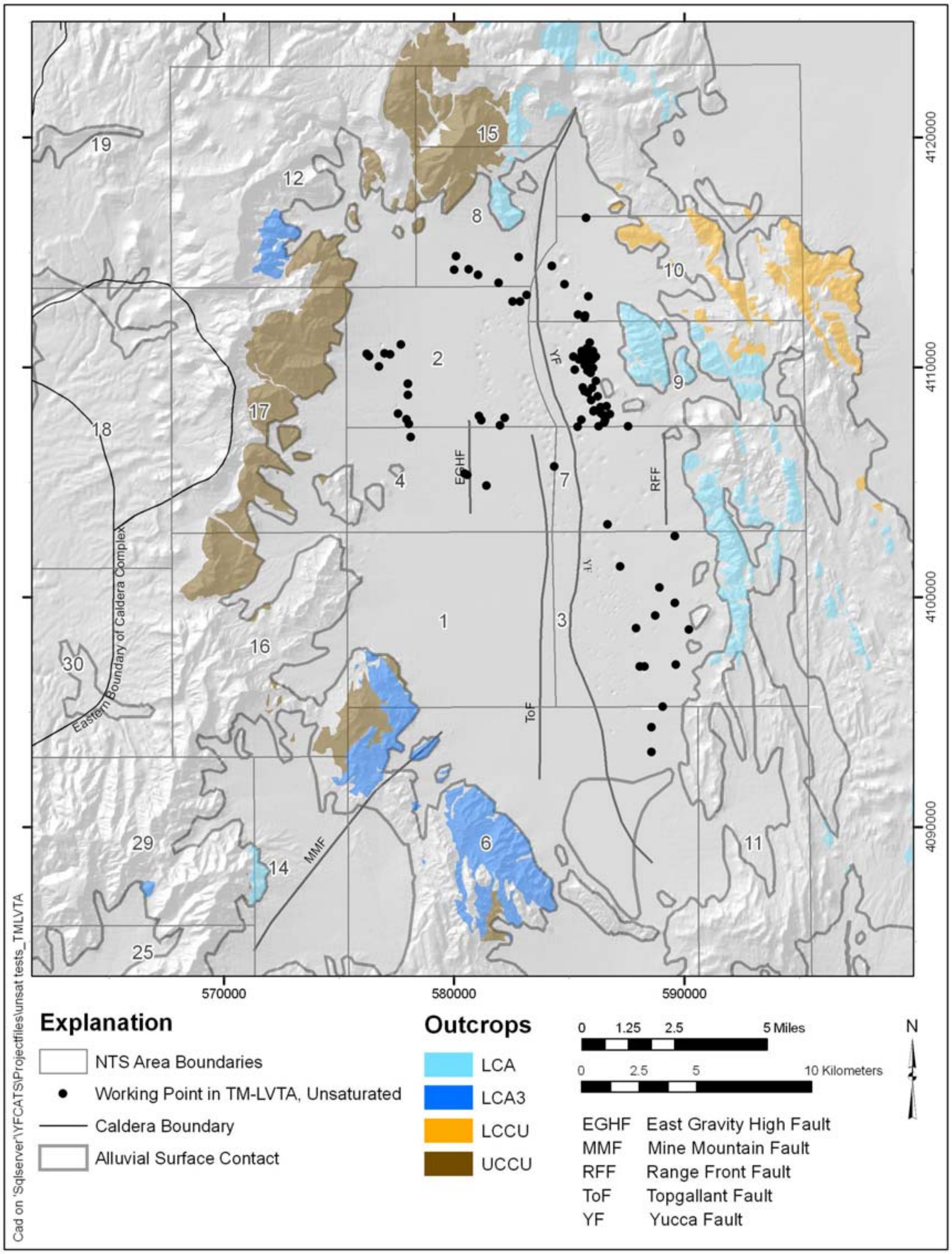

Figure 3.13 Locations of detonations with WP in the unsaturated TM-LVTA.

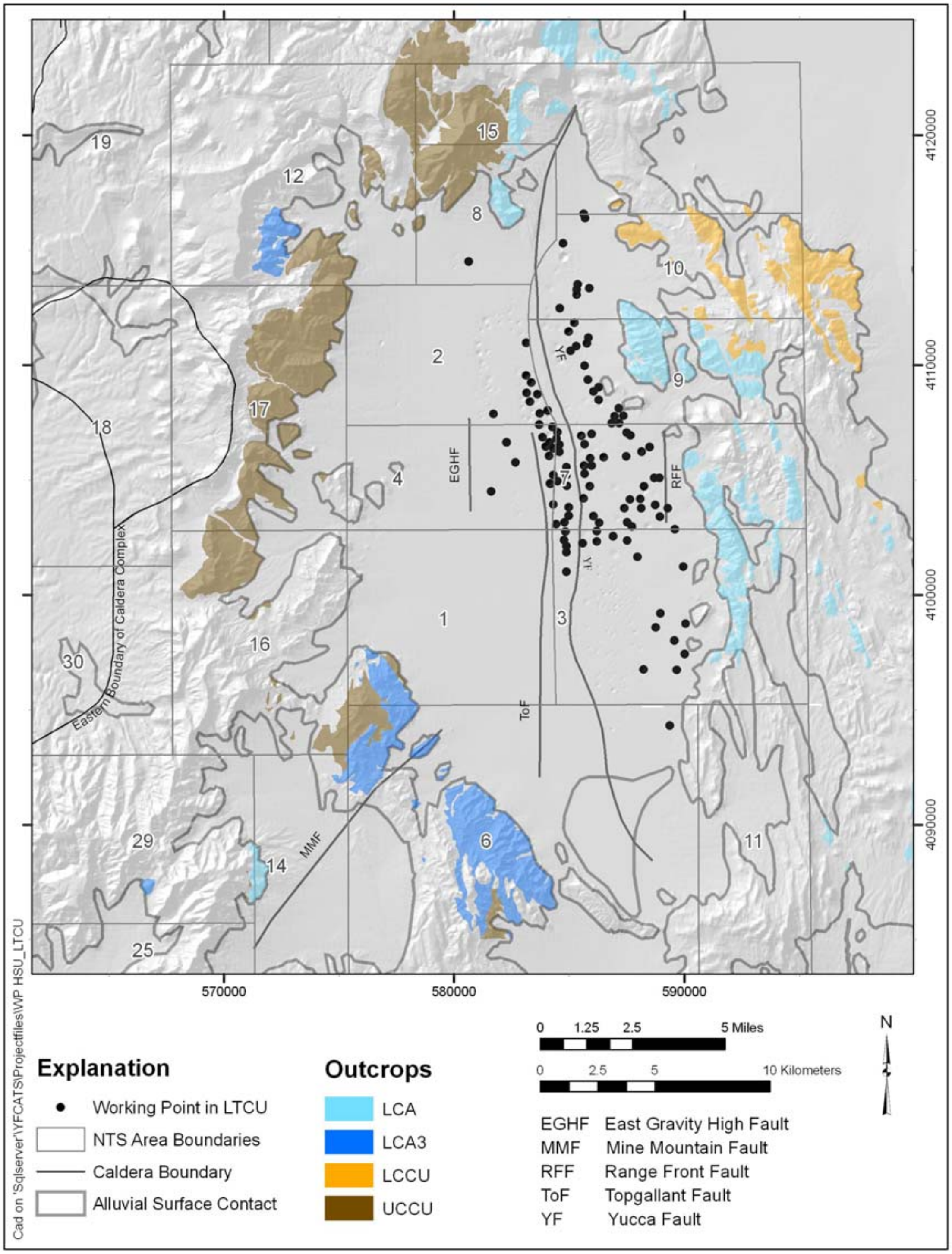

Figure 3.14 Locations of detonations with WP in the LTCU.

Table 3.7 HSU information for the 2-Rc volumes for detonations with WPs in the LTCU.

<table>
<tr><td rowspan="3">ALL DETONATIONS</td><td>minus2Rc</td><td colspan="3">4</td><td colspan="2">14</td><td colspan="5">39</td><td colspan="4">54</td></tr>
<tr><td>WP</td><td colspan="14">111</td></tr>
<tr><td>plus2Rc</td><td>1</td><td>1</td><td>2</td><td>10</td><td>4</td><td>15</td><td>15</td><td>2</td><td>3</td><td>4</td><td>14</td><td>32</td><td>7</td><td>1</td></tr>
<tr><td rowspan="3">SATURATED DETONATIONS</td><td>minus2Rc</td><td colspan="3" rowspan="3"></td><td colspan="2">12</td><td colspan="5">16</td><td colspan="4">41</td></tr>
<tr><td>WP</td><td colspan="11">69</td></tr>
<tr><td>plus2Rc</td><td>8</td><td>4</td><td>8</td><td>5</td><td></td><td>3</td><td></td><td>11</td><td>23</td><td>6</td><td>1</td></tr>
<tr><td rowspan="3">UNSATURATED DETONATIONS</td><td>minus2Rc</td><td colspan="3">4</td><td colspan="2">2</td><td colspan="5">23</td><td colspan="4">13</td></tr>
<tr><td>WP</td><td colspan="14">42</td></tr>
<tr><td>plus2Rc</td><td>1</td><td>1</td><td>2</td><td>2</td><td></td><td>7</td><td>10</td><td>2</td><td></td><td>4</td><td>3</td><td>9</td><td>1</td><td></td></tr>
</table>

Legend (HSUs are identified in Table 1.2)

AA
TM-UVTA
UTCU
TM-WTA
TM-LVTA
LTCU
OSBCU
ATCU
MGCU
LCA3
LCA
UCCU
LCCU

Categories of detonations with WP in the LTCU:

All detonations—14

Saturated detonations—9

Unsaturated detonations—11

About 15% of the detonations in Yucca Flat had WPs in the LTCU, mostly in east central Yucca Flat (Figure 3.14). The EarthVision® model shows that the LTCU is present over much of Yucca Flat, except where the pre-Tertiary rocks are high in western Areas 2, 4, 1, and 6, and where the LCA crops out on the east side of the Yucca Flat basin (Bechtel Nevada, 2006). Detonations with WPs in the LTCU are located east of the East Gravity High Fault in central Area 4 and extend to the outcrop of LCA at easternmost Yucca Flat. Most are located in and north of Areas 4 and 7. A large set of detonations is tightly packed between the Topgallant and Yucca faults. Detonations in Areas 9 and 10 are located about midway between the Yucca Fault and outcrop to the east.

Saturated detonations are located closer to the eastern side of the Topgallant and Yucca faults (Figure 3.15), in the deeper portions of the down-dropped and tilted structural blocks. The unsaturated detonations are located farther east of the faults (Figure 3.16) when compared to the saturated detonations, where they are at a structurally higher elevation and closer to the LCA outcrop to the east.

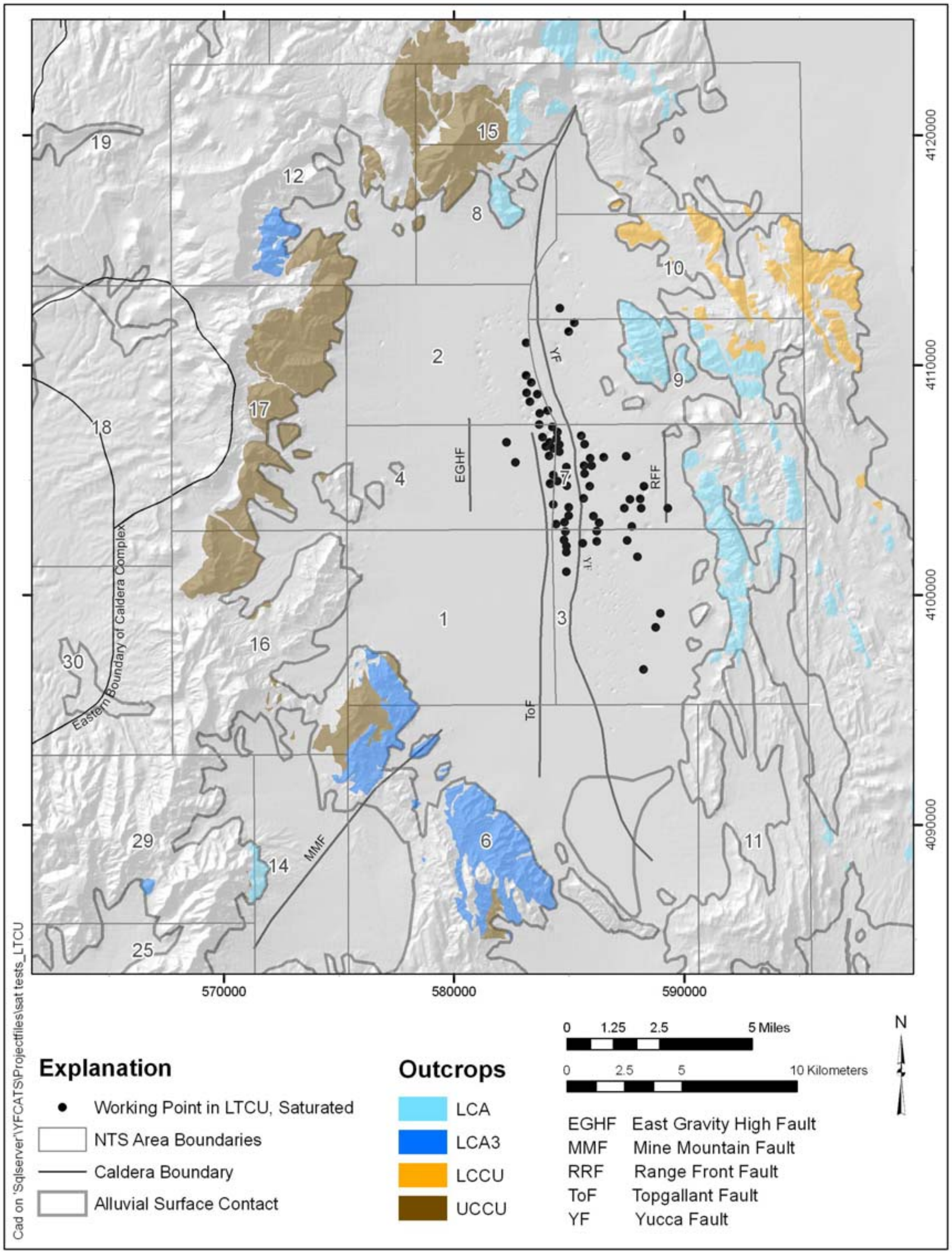

Figure 3.15 Locations of detonations with WP in the saturated LTCU.

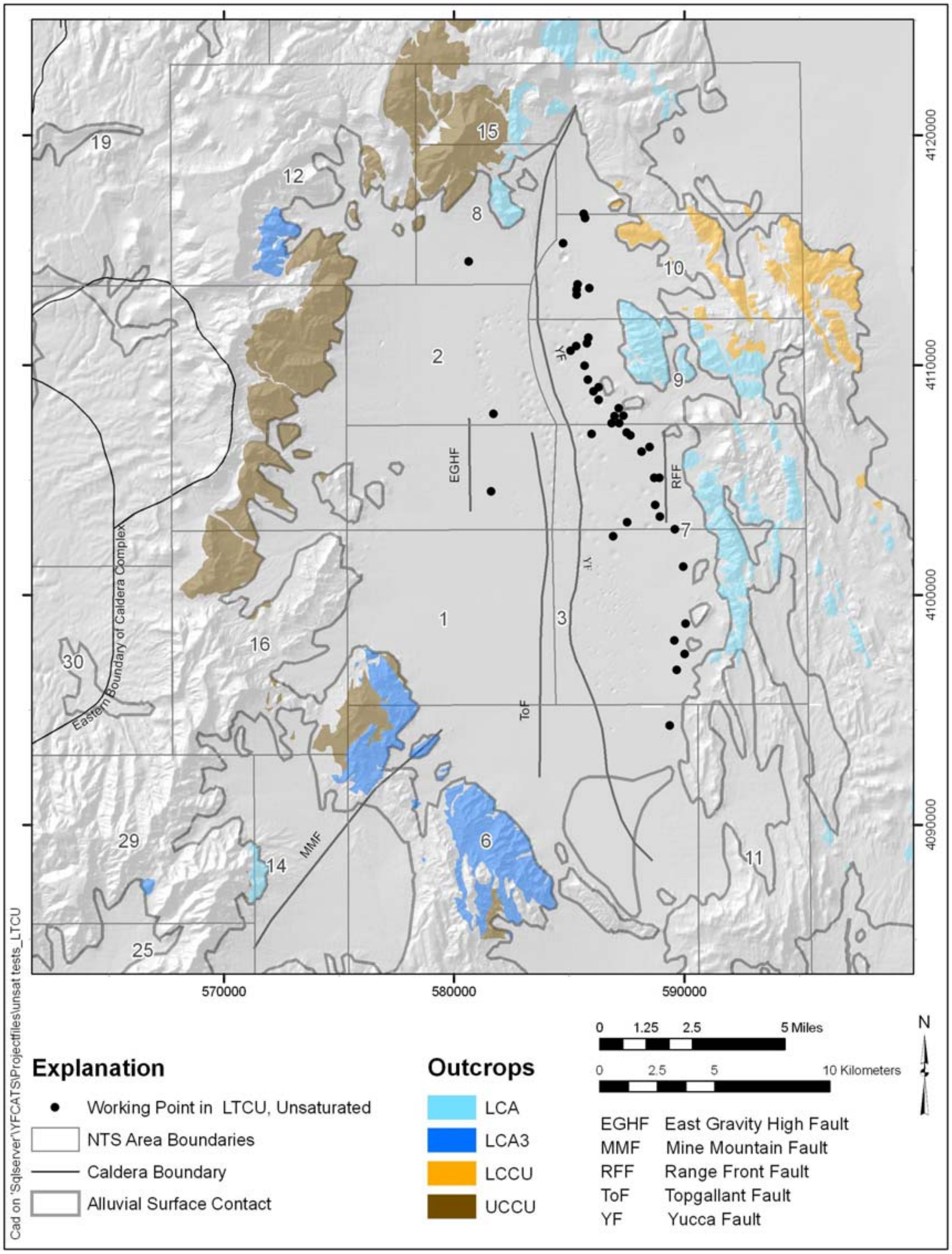

Figure 3.16 Locations of detonations with WP in the unsaturated LTCU.

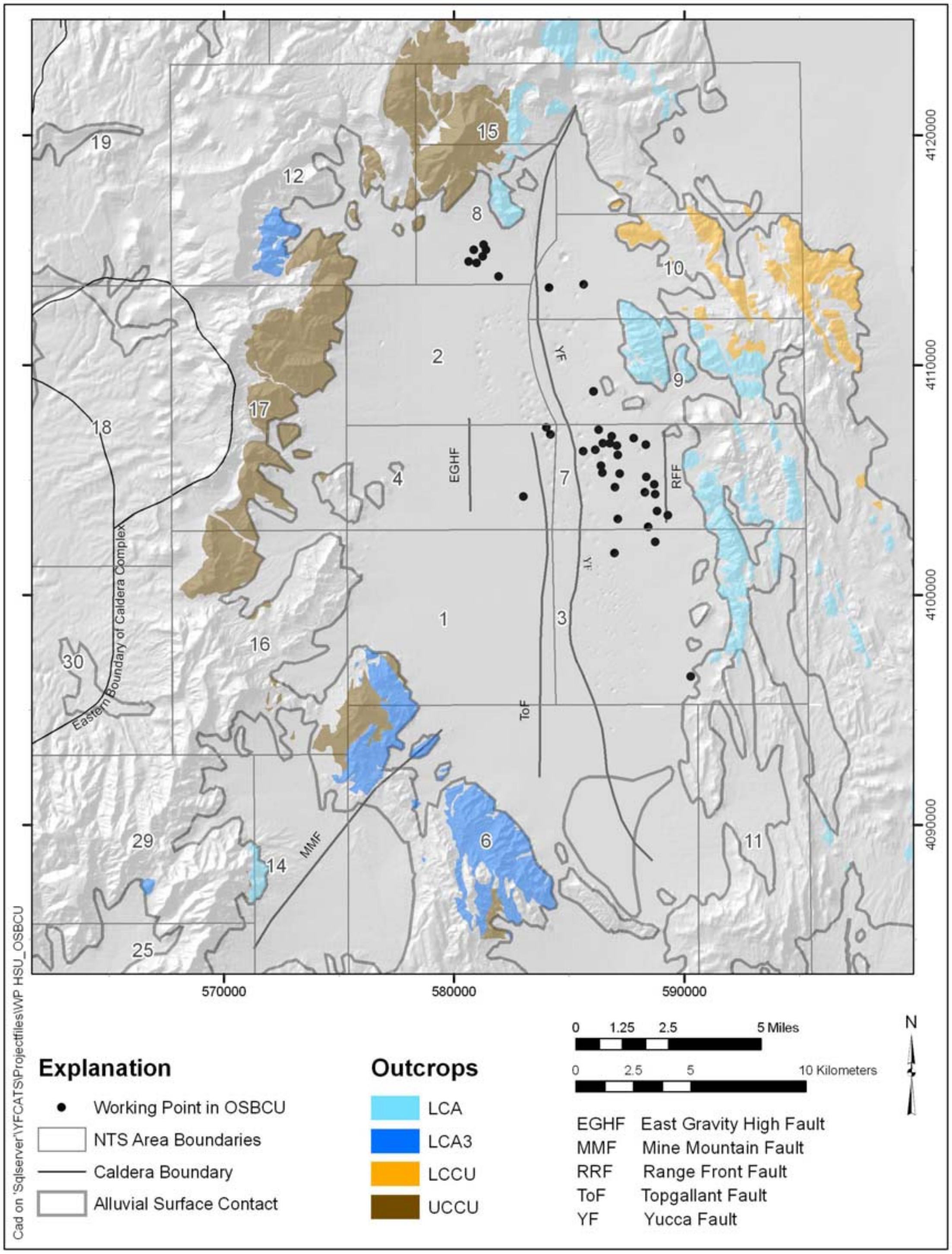

Figure 3.17 Locations of detonations with WP in the OSBCU.

Table 3.8 HSU information for the 2-Rc volumes for detonations with WPs in the OSBCU.

ALL DETONATIONS	minus2Rc	8	28			4	
	WP	39					
	plus2Rc	8	17	5	5	1	3
SATURATED DETONATIONS	minus2Rc	1	20			4	
	WP	25					
	plus2Rc	1	11	5	4	1	3
UNSATURATED DETONATIONS	minus2Rc	7	7				
	WP	14					
	plus2Rc	7	6		1		

Legend (HSUs are identified in Table 1.2)

AA
TM-UVTA
UTCU
TM-WTA
TM-LVTA
LTCU
OSBCU
ATCU
MGCU
LCA3
LCA
UCCU
LCCU

Categories of detonations with WP in the OSBCU:

All detonations—6

Saturated detonations—6

Unsaturated detonations—3

About 5% of the detonations in Yucca Flat had WPs in the OSBCU. The EarthVision® model shows the OSBCU extending from north to south Yucca Flat, in the eastern portions of Areas 1, 2, 4, and 8; westernmost Areas 9 and 10; the western half of Areas 3 and 7, and almost the eastern half of Area 6 (Bechtel Nevada, 2006). As shown in Figure 3.17, detonations with WPs in the OSBCU are roughly located in two clusters— northern Yucca Flat (Areas 8 and 10) and east central Yucca Flat (Areas 3, 4, 7, and 9). The majority of these detonations are located in central Yucca Flat—eastern Area 4, western Area 7, and northwestern Area 3. They are located on the east side of the major faults, and range from just east of the faults to the eastern edge of the basin near outcrops of LCA.

The saturated detonations with WPs in the OSBCU (Figure 3.18) are located on the down-dropped (east) side of major faults. The unsaturated detonations are clustered in Area 8 (Figure 3.19), where the pre-Tertiary rocks are shallower. Other unsaturated detonations are located farther east of the Yucca Fault when compared to the saturated detonations, where they are at a structurally higher elevation and closer to the LCA outcrop to the east.

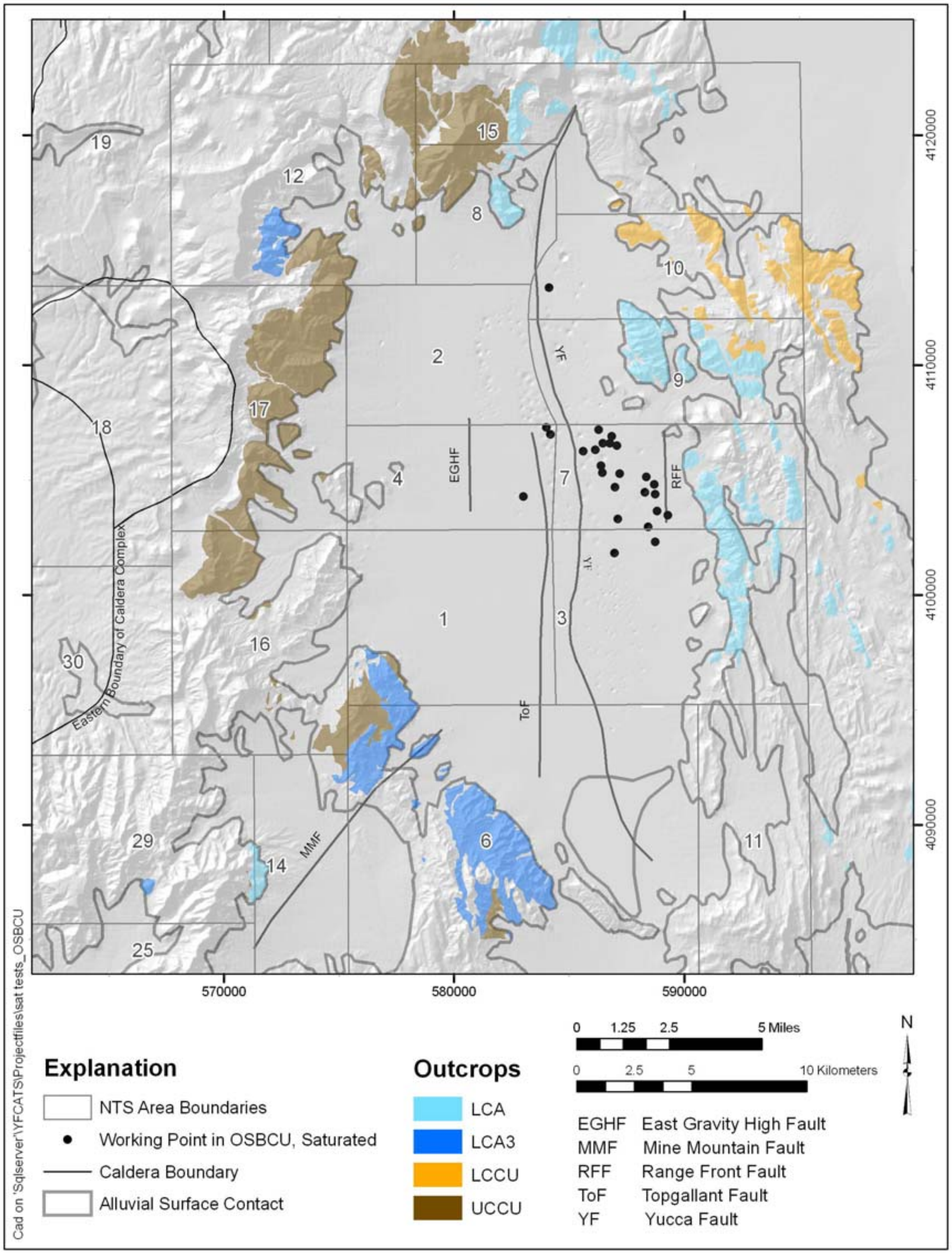

Figure 3.18 Locations of detonations with WP in the saturated OSBCU.

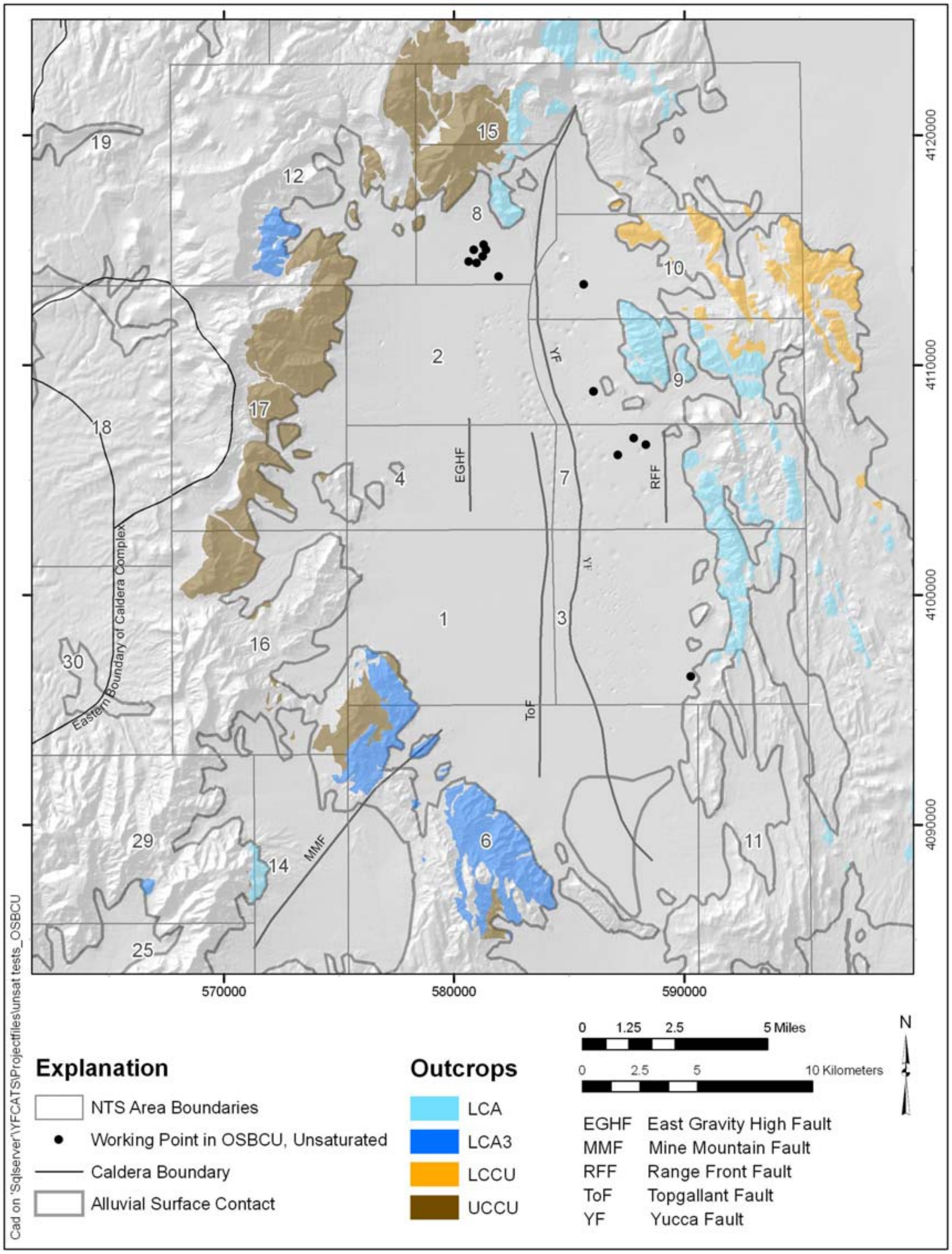

Figure 3.19 Locations of detonations with WP in the unsaturated OSBCU.

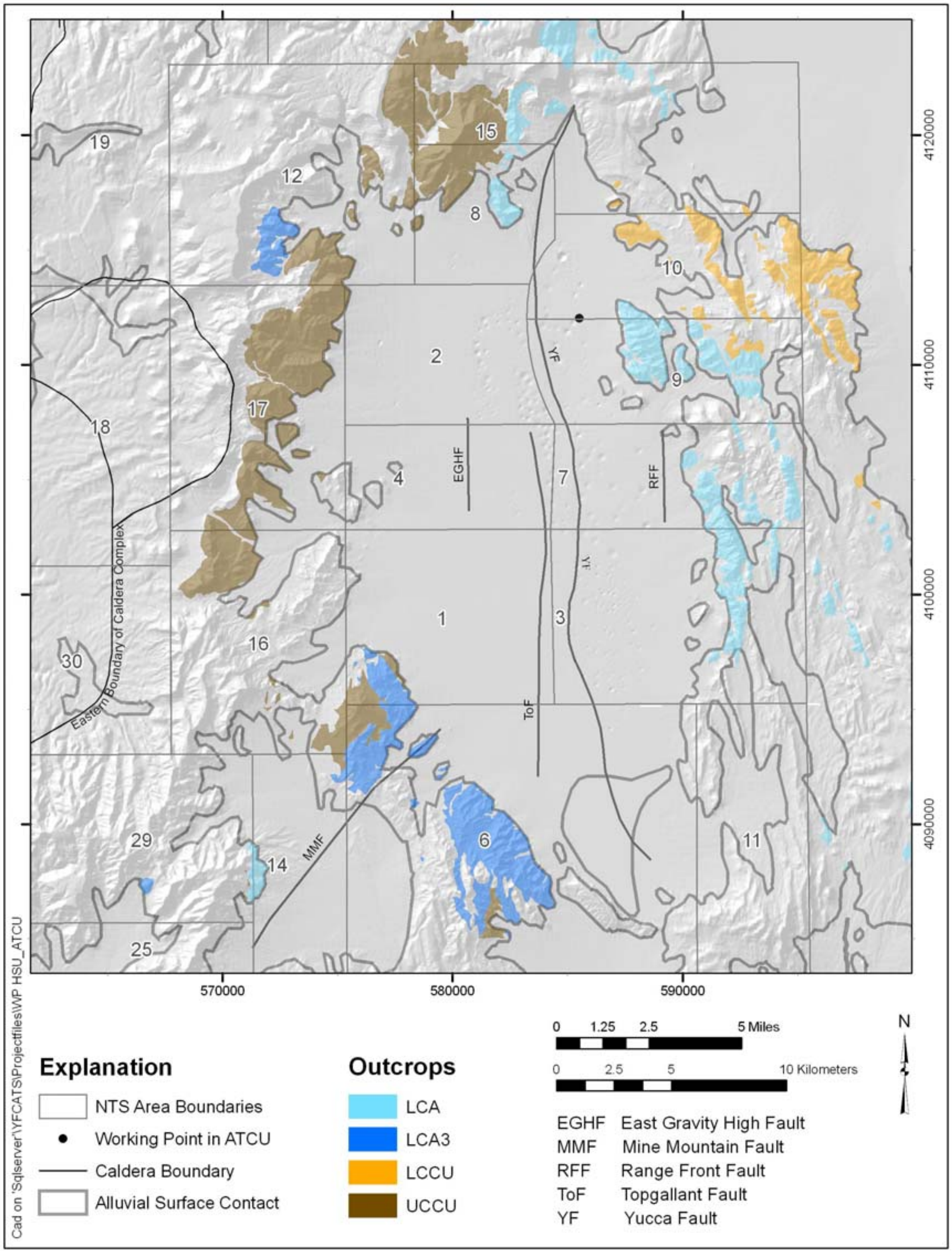

Figure 3.20 Locations of detonations with WP in the ATCU.

Table 3.9 HSU information for the 2-Rc volumes for detonations with WPs in the ATCU.

ALL DETONATIONS	minus2Rc	1
	WP	1
	plus2Rc	1
SATURATED DETONATIONS	minus2Rc	1
	WP	1
	plus2Rc	1

Legend (HSUs are identified in Table 1.2)

AA
TM-UVTA
UTCU
TM-WTA
TM-LVTA
LTCU
OSBCU
ATCU
MGCU
LCA3
LCA
UCCU
LCCU

Categories of detonations with WP in the ATCU:

All detonations—1

Saturated detonations—1

Unsaturated detonations—0

Only one detonation in Yucca Flat has a WP in the ATCU. The EarthVision® model shows that the extent of the ATCU is similar to that of the OSBCU, but the ATCU is also present in the small fault-formed basin in western Areas 1, 2, and 4 (Bechtel Nevada, 2006). This detonation is located in Area 10, about midway between the Yucca Fault and the LCA outcrop to the east (Figure 3.20).

This detonation is saturated, and no separate maps are shown of saturated and unsaturated detonations with WPs in the ATCU.

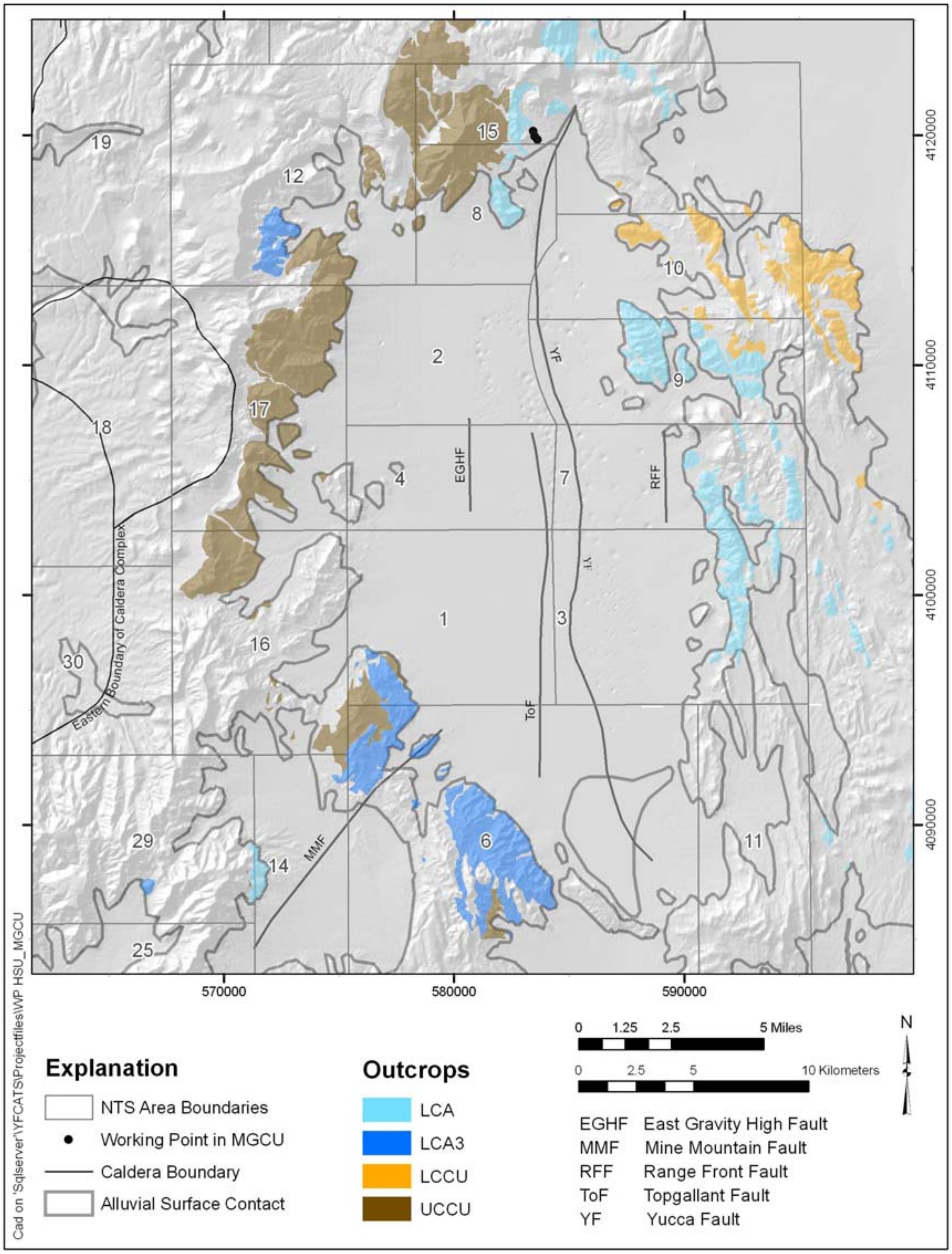

Figure 3.21 Locations of detonations with WP in the MGCU.

Table 3.10 HSU information for the 2-Rc volumes for detonations with WPs in the MGCU.

ALL DETONATIONS	minus2Rc	3	
	WP	3	
	plus2Rc	3	
SATURATED DETONATIONS	minus2Rc	2	
	WP	2	
	plus2Rc	2	
UNSATURATED DETONATIONS	minus2Rc		1
	WP		1
	plus2Rc		1

Legend (HSUs are identified in Table 1.2)

AA
TM-UVTA
UTCU
TM-WTA
TM-LVTA
LTCU
OSBCU
ATCU
MGCU
LCA3
LCA
UCCU
LCCU

Categories of detonations for WPs in the MGCU:

All Detonations—1

Saturated detonations—1

Unsaturated detonations—1

Less than 1% of the detonations in the Yucca Flat/Climax Mine CAU had WPs in the MGCU. As shown in Figure 3.21, these three detonations were in granitic intrusive rocks of the Climax Stock in Area 15. The WPs for two of the detonations are saturated (Figure 3.22), while one is unsaturated (Figure 3.23).

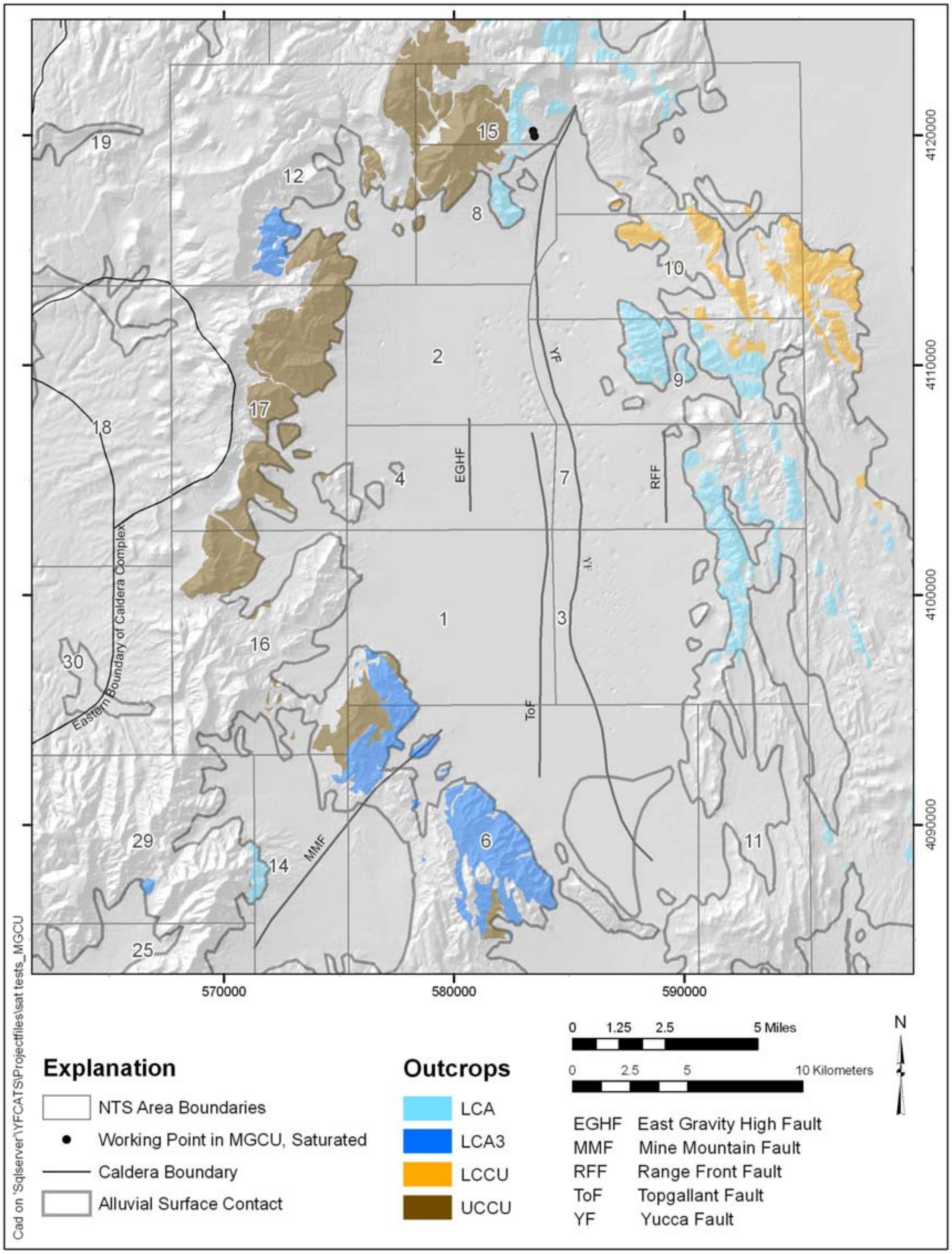

Figure 3.22 Locations of detonations with WP in the saturated MGCU.

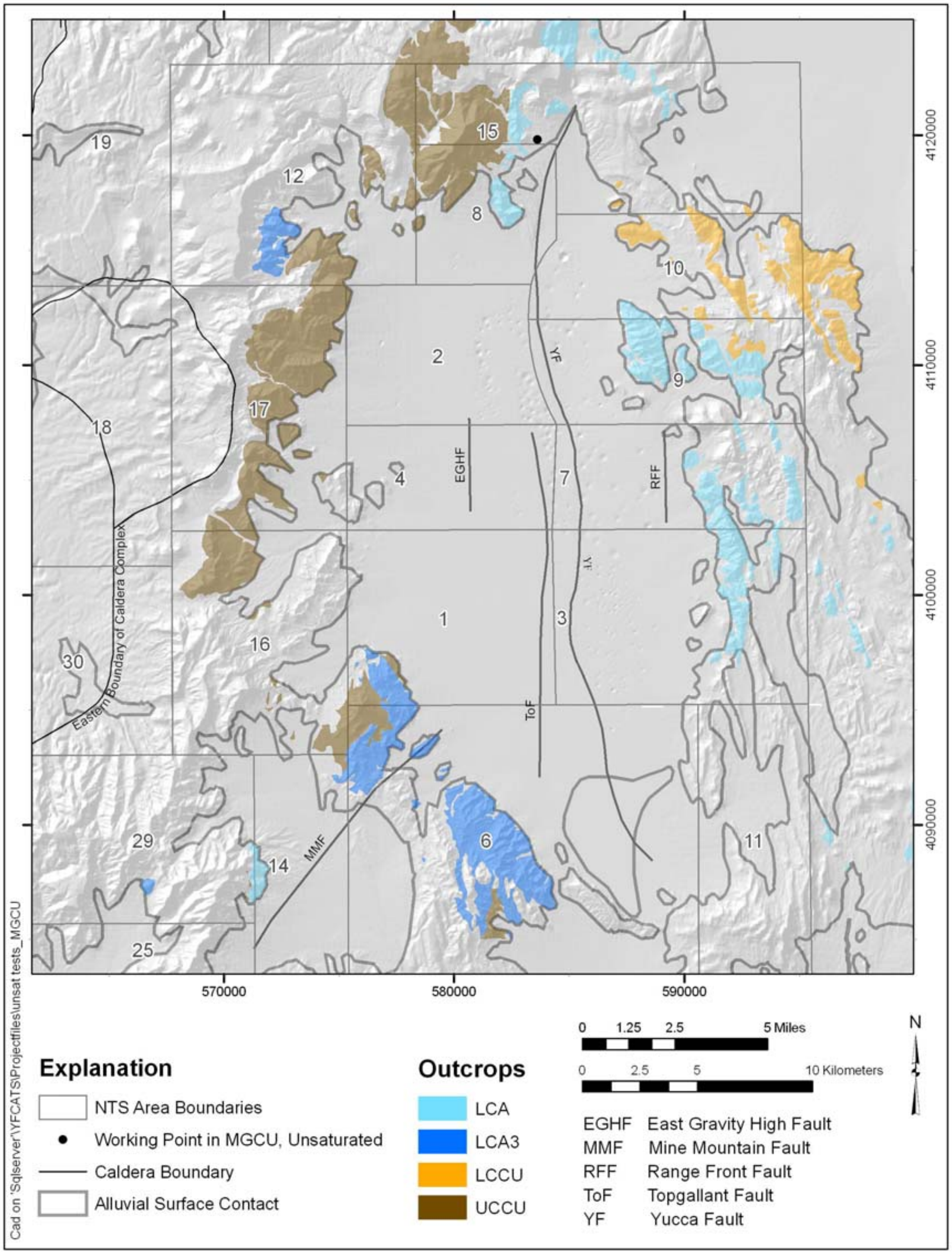

Figure 3.23 Locations of detonations with WP in the unsaturated MGCU.

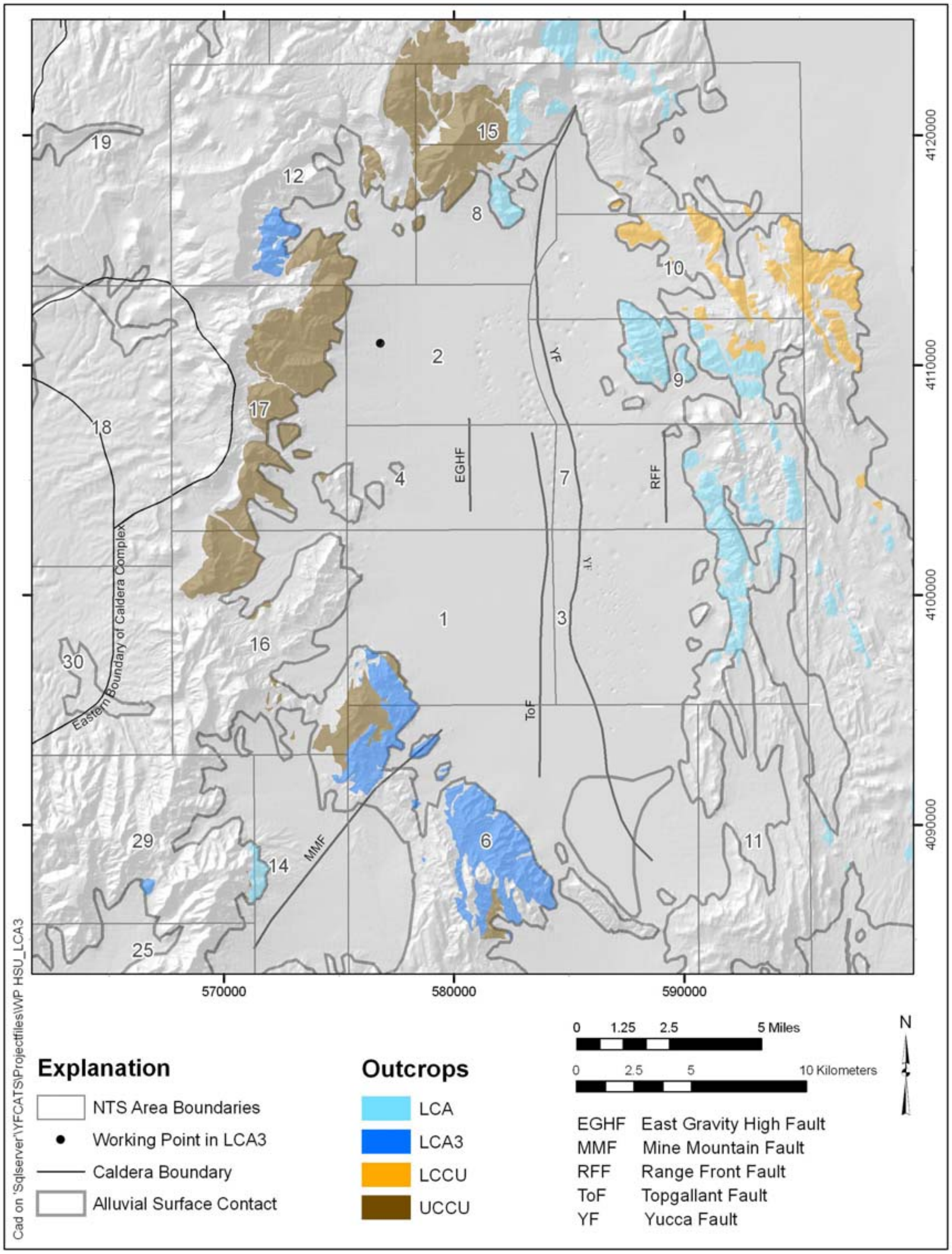

Figure 3.24 Locations of detonations with WP in the LCA3.

Table 3.11 HSU information for the 2-Rc volumes for detonations with WPs in the LCA3.

ALL DETONATIONS	minus2Rc	1
	WP	1
	plus2Rc	1
SATURATED DETONATIONS	minus2Rc	
	WP	
	plus2Rc	
UNSATURATED DETONATIONS	minus2Rc	1
	WP	1
	plus2Rc	1

Legend (HSUs are identified in Table 1.2)

AA
TM-UVTA
UTCU
TM-WTA
TM-LVTA
LTCU
OSBCU
ATCU
MGCU
LCA3
LCA
UCCU
LCCU

Categories of detonations with WPs in the LCA3:

All detonations—1

Saturated detonations—0

Unsaturated detonations—1

Only one detonation in Yucca Flat has a WP in the LCA3 (Figure 3.24). The EarthVision® model shows the LCA3, the lower carbonate thrust plate, present on the west side of Yucca Flat, extending about half-way to two-thirds of the way eastward through Areas 1, 2, 4, and 6 (Bechtel Nevada, 2006).

This detonation is unsaturated. No separate maps are shown of saturated and unsaturated detonations with WPs in LCA3.

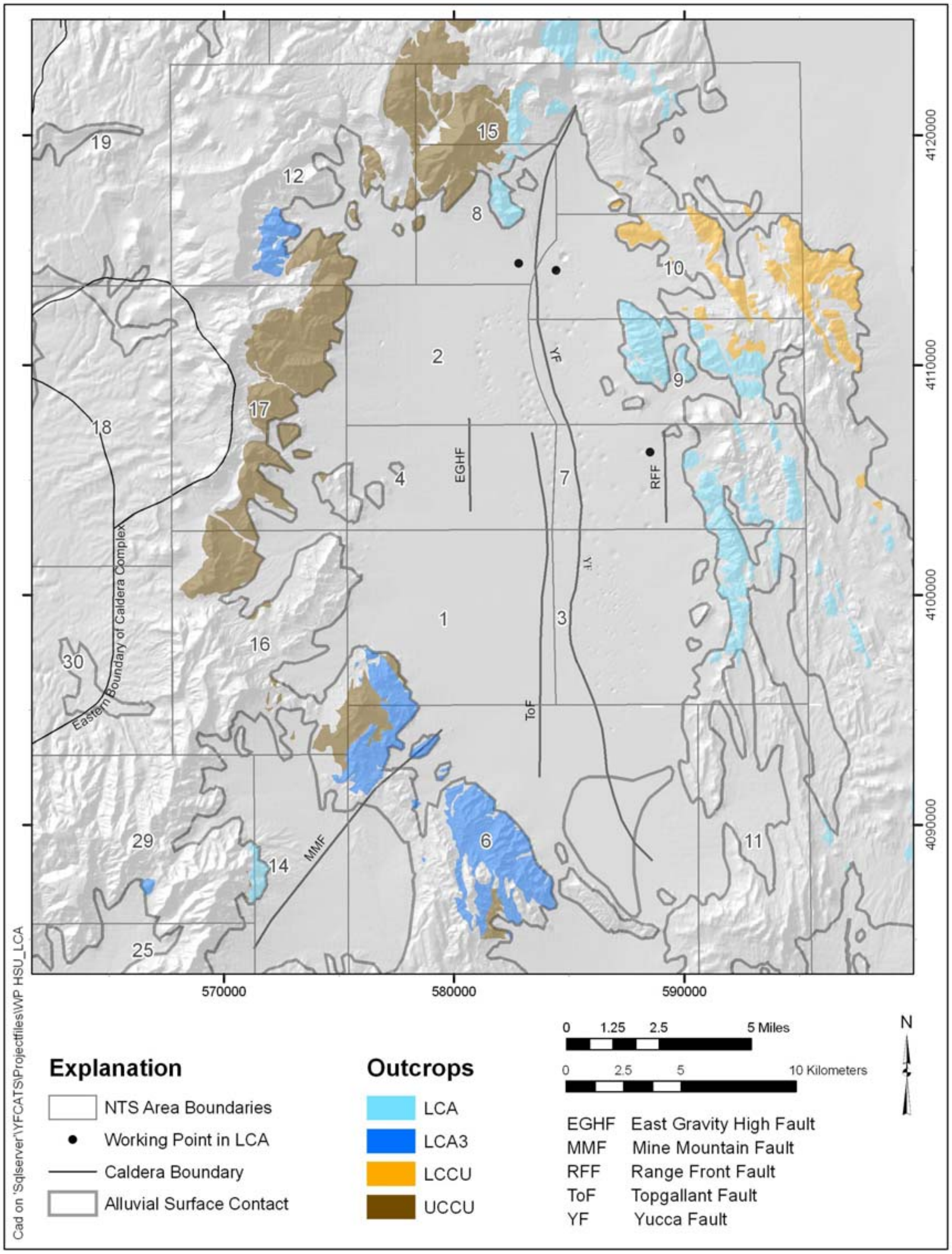

Figure 3.25 Locations of detonations with WP in the LCA.

Table 3.12 HSU information for the 2-Rc volumes for detonations with WPs in the LCA.

ALL DETONATIONS	minus2Rc	1	1	1
	WP		3	
	plus2Rc		3	
SATURATED DETONATIONS	minus2Rc		1	
	WP		1	
	plus2Rc		1	
UNSATURATED DETONATIONS	minus2Rc	1		1
	WP		2	
	plus2Rc	1		1

Legend (HSUs are identified in Table 1.2)

AA
TM-UVTA
UTCU
TM-WTA
TM-LVTA
LTCU
OSBCU
ATCU
MGCU
LCA3
LCA
UCCU
LCCU

Categories of detonations with WPs in the LCA:

All detonations—3

Saturated detonations—1

Unsaturated detonations—2

Three detonations in Yucca Flat had WPs in the LCA. The EarthVision® model shows that the LCA underlies the entire Yucca Flat basin, with the exception of where the LCCU outcrops in eastern Areas 9, 10, and 15 (Bechtel Nevada, 2006). As shown in Figure 3.25, these three detonations are located in Areas 7, 8, and 10 (although the hole in Area 8 is named U-10b). All three holes are located near the edges of the basin, where the overlying alluvium and volcanic sections are thinner. Note that the upper 2-Rc (WP minus 2-Rc) of the U-10b hole, located west of the Yucca Fault, is in alluvium, while the WP and lower 2-Rc (WP plus 2-Rc) are in the LCA. The upper 2-Rc for U-10p, located east of Yucca Fault, is in the LTCU and the WP and lower 2-Rc are in the LCA. The entire interval (upper 2-Rc/WP/lower 2-Rc) for U-7n is in the LCA. The detonation in Area 7 is saturated (Figure 3.26), while the two detonations in northern Yucca Flat are unsaturated (Figure 3.27).

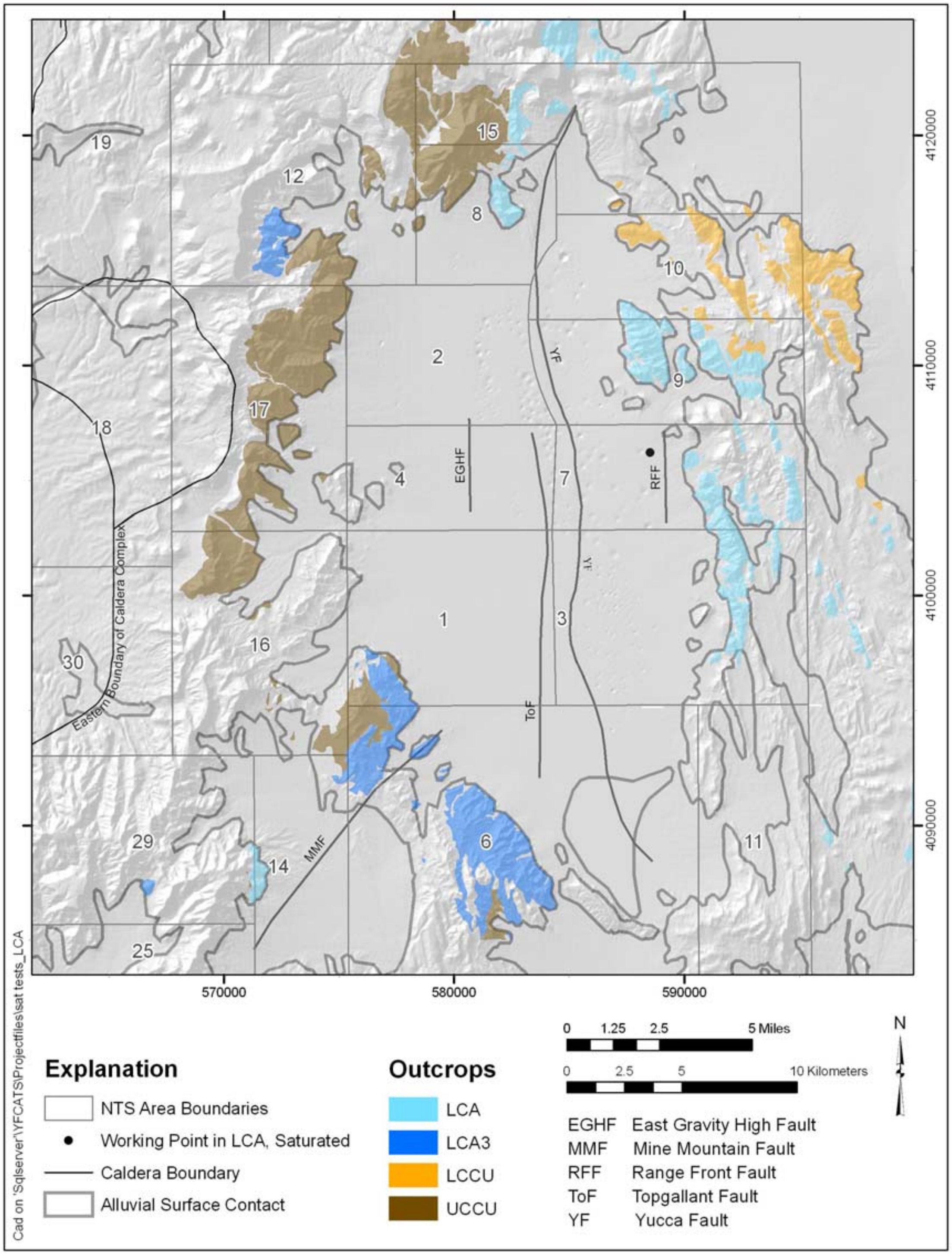

Figure 3.26 Locations of detonations with WP in the saturated LCA.

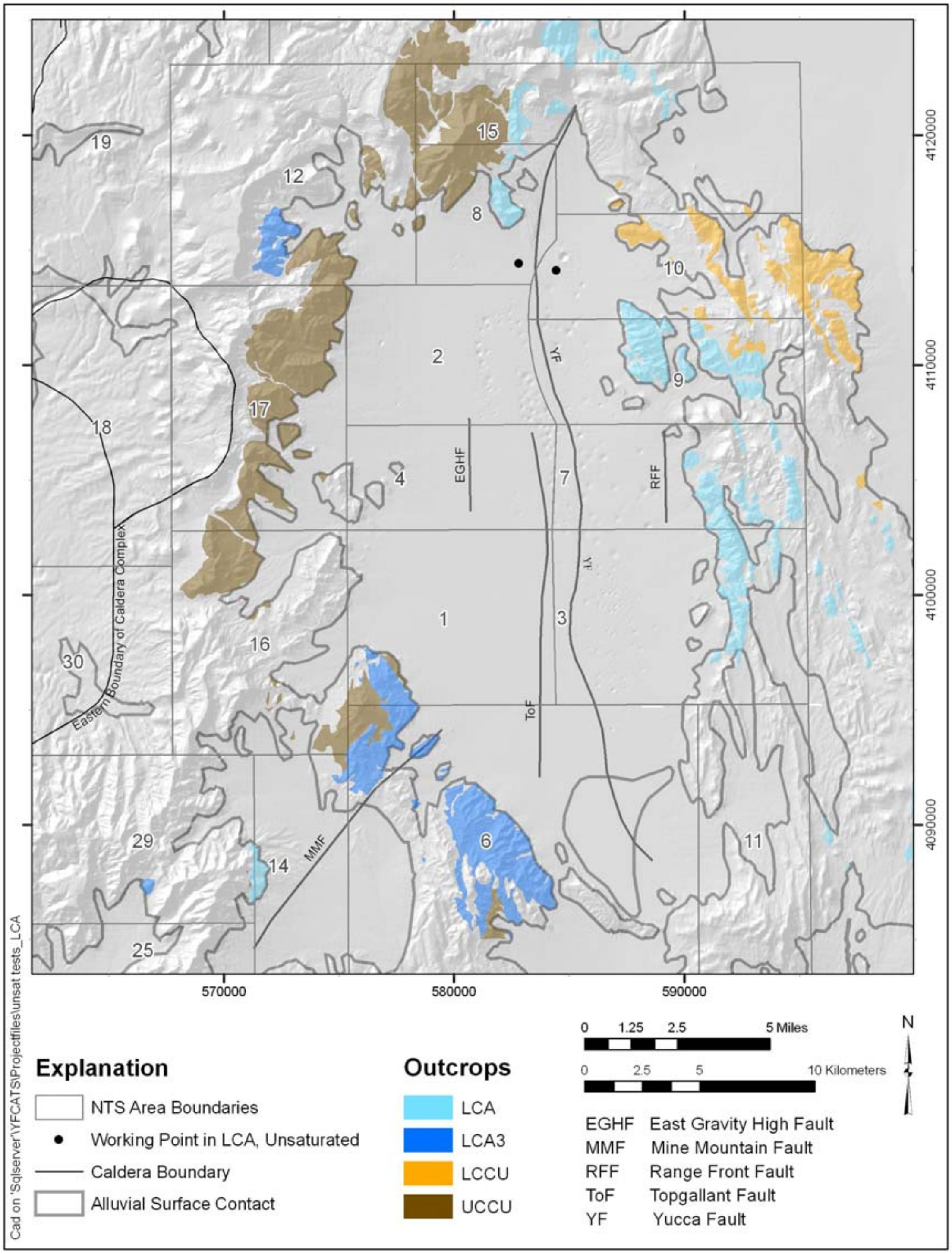

Figure 3.27 Locations of detonations with WP in the unsaturated LCA.

3.3 Discussion of HSU Data

Combinations of HSUs at minus 2-Rc/WP/plus 2-Rc volumes were examined to see if common categories could be identified, thus reducing the total number of detonations that will need to be uniquely modeled for radionuclide transport. Table 3.13 shows that 62 categories can be formed for all 747 detonations in shafts and tunnels in Yucca Flat, 37 categories for all 170 saturated detonations, and 52 categories for all 577 unsaturated detonations. This significantly reduces the number of simulations necessary to calculate the source term for CAU transport modeling.

Interesting patterns emerge when maps of WP HSUs are viewed in stratigraphic order. However, an understanding of the structure of Yucca Flat is necessary to understand these patterns. This description of Yucca Flat has been generalized from documentation for the Yucca Flat hydrostratigraphic framework model (Bechtel Nevada, 2006).

East- to southeast-directed thrusting along the Belted Range Thrust Fault resulted in complex contractional deformation within the pre-Tertiary rocks along the present western margin of Yucca Flat. Imbricate thrusting created a complex stack of thrust slices. A west-vergent CP Thrust Fault formed a high-angle ramp in what is now the central portion of Yucca Flat. East-west extension resulted in the formation of basins, such as Frenchman Flat, Yucca Flat, Emigrant Valley, and Kawich Valley, by displacements along west-dipping high angle normal faults located on the eastern margins of developing basins. This also resulted in an eastward tilt to stratigraphic units. In Yucca Flat, however, reactivation of the east-dipping high-angle ramp structure related to the CP Thrust resulted in the formation of the east-dipping Carpetbag-Topgallant fault system near the center of the present Yucca Flat topographic basin and the formation of the west-tilted Yucca Flat structural system (shown here as Figure 3.28, which is Figure 4-4 from Bechtel Nevada, 2006).

Yucca Flat consists of two structural basins separated by a narrow structural ridge (shown here as Figure 3.29, which is Figure 3-2 from Bechtel Nevada, 2006). The main Yucca Flat basin lies beneath central and east Yucca Flat, east of the Carpetbag-Topgallant fault system. This basin consists of two main west-tilted half grabens formed by dip-slip movement along the north-striking and east-dipping Carpetbag-Topgallant and Yucca fault systems. Movement on antithetic and synthetic faults created smaller subbasins, resulting in numerous parallel, north-striking sub-basins beneath the eastern half of Yucca Flat.

The Carpetbag-Topgallant fault system forms the eastern flank of a narrow ridge that separates the main Yucca Flat basin from a smaller structural subbasin beneath the western portion of Yucca Flat. This subbasin is a graben bounded by normal faults on the west and east. The basin is narrower and shallower than the main basin to the east.

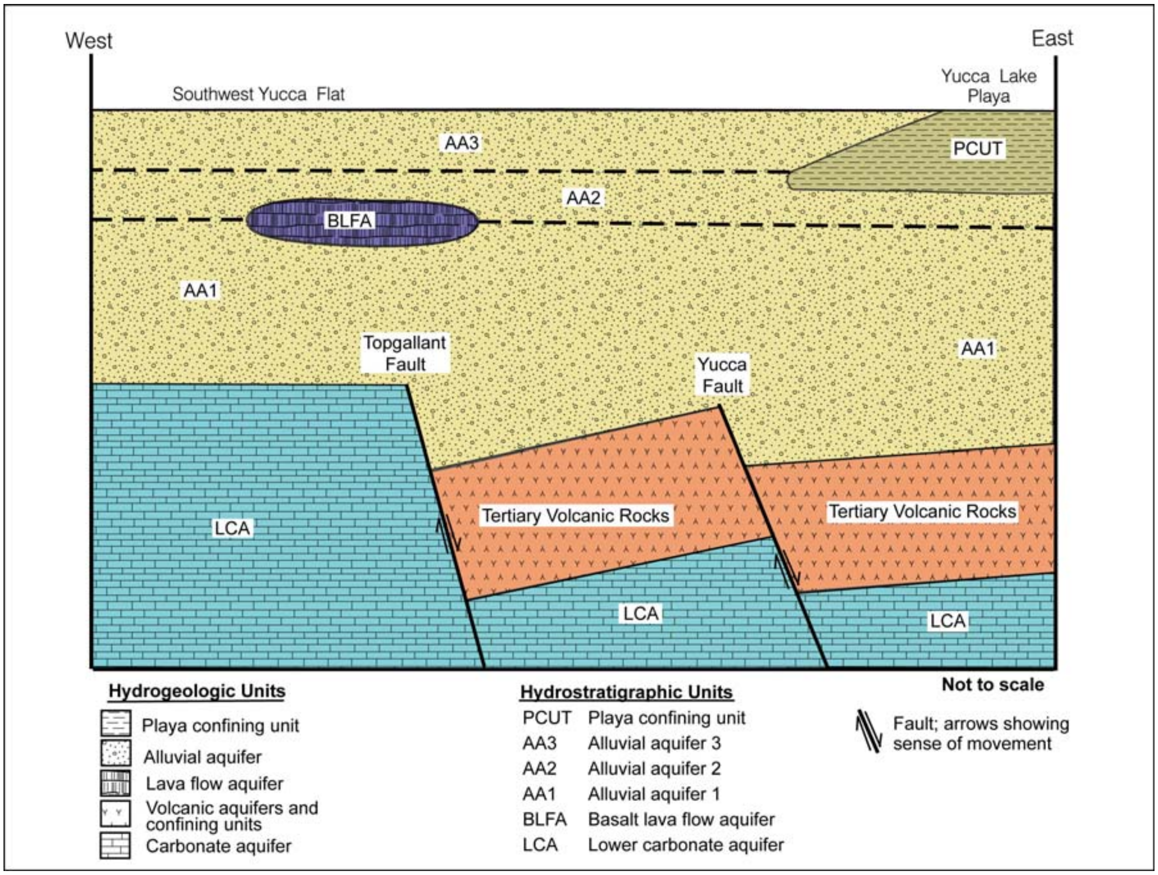

Figure 3.28 A schematic showing relationships of tilted and rotated fault blocks in southern Yucca Flat (Figure 4-4 from Bechtel Nevada, 2006).

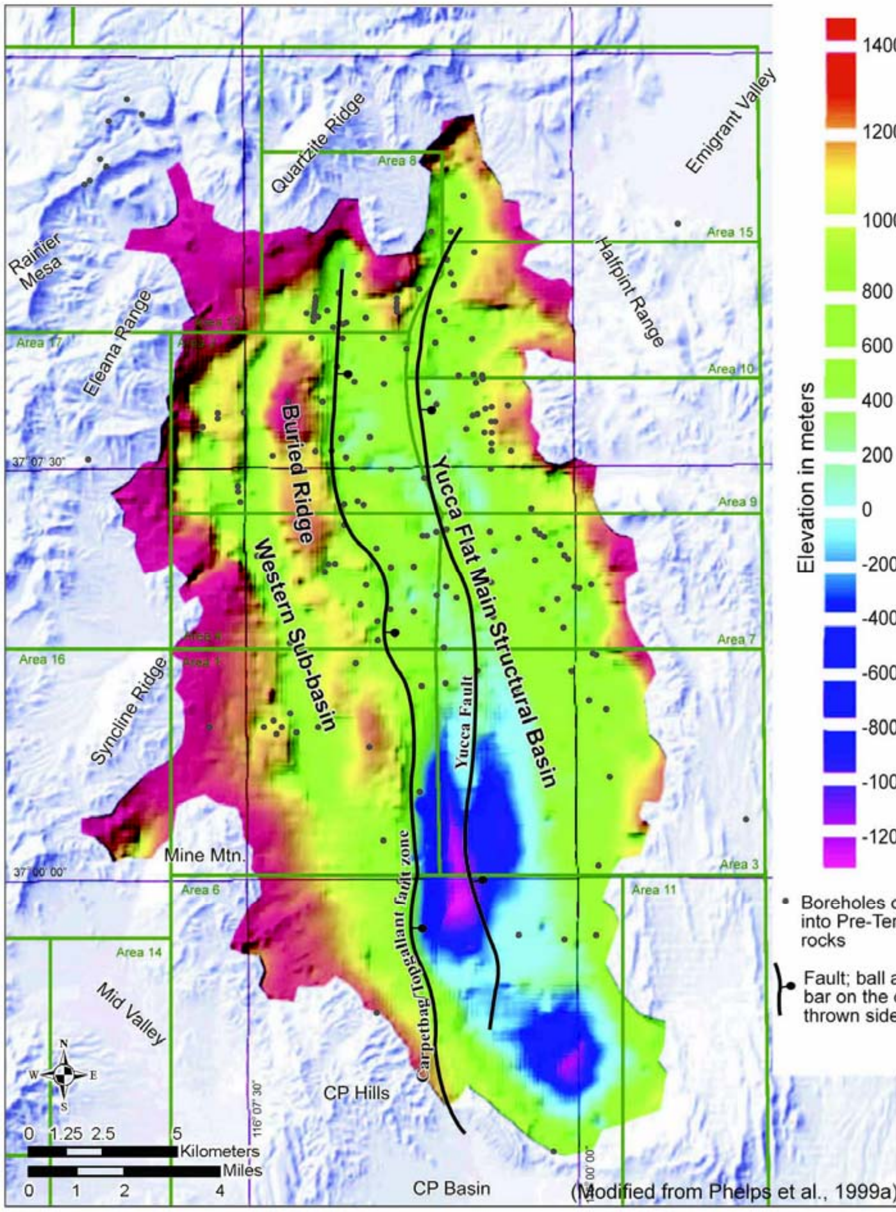

Figure 3.29 Color elevation relief map of the pre-Tertiary surface beneath Yucca Flat based on gravity data (as presented in Bechtel Nevada (2006), modified from Phelps et al., (1999)).

The following general patterns of WP HSUs have been identified, starting with the oldest HSU:

- No detonations are located in southwest Yucca Flat (most of Area 1), where the thrusted pre-Tertiary rocks are high. Tuff and alluvial deposits are relatively thin, and at times volcanic units are not present (alluvium overlies LCA3).
- Detonations with WP in the LCA are located at the northern and eastern basin edges, where pre-Tertiary rocks were structurally high and depositional fill is thin. The two detonations in Area 10 at the north end of Yucca Flat basin are unsaturated, while the detonation in Area 7, located centrally in the basin in a north-south sense, is saturated.
- Detonations with WP in the LCA3 are located in western Area 2, where the CP Thrust raises the carbonate aquifer and overlying deposits are thin. This detonation is unsaturated.
- Detonations with WP in the MGCU are constrained to Area 15 in northern Yucca Flat, where the stock is located close to the ground surface. The three detonations are relatively closely located, compared to the size of Yucca Flat. The difference in saturated and unsaturated detonations is that one unsaturated detonation had a shallower WP depth. At this detonation location, the water is perched.
- Detonations with WP in the ATCU are located east of the Yucca Fault, midway between the fault and pre-Tertiary outcrop to the east.
- Detonations with WP in the OSBCU are located in two main areas: in the north—a cluster of detonations in Area 8 and some detonations in Area 10, and in the south central—detonations located in Areas 7 and 3. The OSBCU detonations in Areas 8 and 10 are in the shallower portion of the basin to the north, while the detonations in Areas 7 and 3 are in tilted fault blocks east of the Topgallant and Yucca fault. Saturated detonations are mainly in Area 7. Unsaturated detonations are the cluster in Area 8, and scattered detonations in Areas 3, 7, 9, and 10 that are midway between Yucca Fault and the pre-Tertiary outcrop to the east.
- Detonations with WP in the LTCU are located east of the East Gravity High Fault, and spread from this fault to pre-Tertiary outcrop to the east. These detonations are located in Areas 3, 4, 7, 8, 9, and 10. Saturated detonations are located between the Topgallant and Yucca faults (the deeper portion of the basin), and between the Yucca Fault and the outcrop to the east (in tilted fault blocks).
- Detonations with WP in the TM-LVTA are located over almost all of Yucca Flat, but not the southwest quarter where the thrusted pre-Tertiary rocks are high. More detonations are located in northern Yucca Flat, Areas 2, 8, 9, and 10, than southern Yucca Flat, Areas 3, 4, and 7. Detonations are also located

in the subbasin in western Areas 2 and 4. Saturated detonations tend to be located in the central portions of the main basin and the subbasin in western Areas 2 and 4. Unsaturated detonations are located closer to the main basin edges than the saturated detonations. Detonations east of Yucca Fault are located about midway between the fault and outcrop to the east.

- Detonations with WP in the TM-WTA are located in the northern (Areas 2 and 9) and southern (Area 3) portions of Yucca Flat, with a few detonations scattered in Area 4. Saturated detonations are located in the central portion of the structural block between the Topgallant and Yucca faults. In Areas 3 and 9, unsaturated detonations are located east of the major faults, about midway between the faults and the outcrops to the east.
- Detonations with WP in the TM-UVTA are located centrally to the Topgallant and Yucca faults. Saturated detonations are located closer to faults were the down-dropped and tilted blocks provide thicker depositional sections. Unsaturated detonations are located farther east from the faults than detonations in all older tuff HSUs.
- Detonations with WP in the AA are located in two main areas—north Yucca Flat (Areas 2, 8, 9, and 10) and south Yucca Flat (Areas 1, 3, and 6). A few detonations are scattered in Area 4. Saturated detonations are located between the East Gravity High Fault and east of the Yucca Fault, in the deeper portions of the basin. Unsaturated detonations are located in two groups—north (Areas 2, 8, 9, and 10) and south (Areas 1, 3, and 6). There are a few scattered detonations in Areas 4 and 7.

Locations of WP HSUs correlate to the structural shape of the basin. Detonations with a WP in carbonate aquifers are near the main basin boundaries or in the uplifted thrusted area to the west, where the rocks are closer to the ground surface. Detonations with a WP in older altered tuff HSUs (ATCU, OSBCU, and LTCU) are located near the basin boundaries, but inside the locations of carbonate WPs, and in thicker depositional sections in the down-dropped and tilted fault blocks. Detonations with a WP in vitric tuffs (TM-LVTA and TM-UVTA) are located in the more central part of the basin and in depositional sections in the down-dropped and tilted fault blocks, but generally in thinner portions of the section. Detonations with a WP in welded tuff (TSA and TM-WTA) are located centrally to the major faults and in portions of the depositional sections in the down-dropped and tilted fault blocks. No welded tuff is present in northernmost Yucca Flat. Detonations with a WP in the AA are mainly located in a wide swath east of the major faults. In general, saturated WPs are located in deeper portions of the basin.

Of special concern are detonations that might introduce radionuclides directly into carbonate rocks, which are part of the regional aquifer underlying the NTS. Four detonations had a WP in the carbonate aquifer (LCA and LCA3). Only one of these detonations is considered a saturated detonation. However, 19 detonations had a portion of their 2-Rc volume touching carbonate rocks (this includes the detonations with WP in LCA3 and LCA). Fifteen of the 45 detonations are considered saturated, and 30 are unsaturated.

There are 28 detonations with WPs in the TM-WTA, but none of these detonations affect the carbonate aquifer; i.e. no part of the 2-cavity radius volume from the welded tuff aquifer extends into carbonate rocks, which could place aquifer against aquifer.

Table 3.13 Preliminary categories for WPs in HSUs.

	Number of detonations with WP	Combinations determined for all detonations	Number of detonations with saturated WP	Combinations determined for saturated detonations	Number of detonations with unsaturated WPs	Combinations determined for unsaturated WPs
AA	415	8	28	5	387	8
TM-UVTA	17	3	5	2	12	2
UTCU	2	2	0	0	2	2
TM-WTA	27	7	7	3	20	7
TM-LVTA	128	16	32	9	96	15
LTCU	111	14	69	9	42	11
OSBCU	39	6	25	6	14	3
ATCU	1	1	1	1	0	0
MGCU	3	1	2	1	1	1
LCA3	1	1	0	0	1	1
LCA	3	3	1	1	2	2
Total	747	62	170	37	577	52

3.4 Analysis of Grouped HSU Data

Combinations of HSUs at minus 2-Rc/WP/plus 2-Rc volumes formed 62 categories for all 747 detonations in shafts and tunnels in Yucca Flat, 37 categories for all 170 saturated detonations, and 52 categories for all 577 unsaturated detonations (Table 3.13). In an attempt to further reduce the number of categories created above, similar HSUs were grouped and analyzed. What this effectively does is group by hydrogeology instead of hydrostratigraphy (Table 1.2). This reduces the units to AA, WTA, VTA, TCU, and LCA. These groupings were justified because individual HSUs have similar flow and transport properties, but are separately identified in the EarthVision® model to retain unique depth positioning. Although other HSUs may occur stratigraphically between the grouped units, the intent is that the grouped units would display similar parameter values in the models.

First, the TM-UVTA and TM-LVTA were combined to form the vitric tuff aquifer (VTA), a grouped HSU that occurs below the AA but above the tuff confining units, as shown in Figure 3.30. The UTCU, which is positioned below the TM-LVTA but above the TSA when TM-WTA or TSA is present, hosted only two detonations, and they are counted in the grouped TCU. As before, WPs in the TSA are included with the TM-WTA.

The second grouping was the tuff confining units below the TM-LVTA, which included the LTCU, OSBCU, and the ATCU, all altered tuffs (Figure 3.31). The UTCU was ignored in this grouping evaluation because it is separated from the other altered tuffs by the TM-LVTA. While the altered tuffs display similar flow properties, they have identifiably different mineralogy, which was the justification for subdividing the tuff confining unit in the TCU study (Prothro, 2005).

Two carbonate aquifers (LCA3 and LCA) are included in the Yucca Flat EarthVision® model. Both have similar flow and transport properties, but are identified separately due to structural position. These carbonate aquifers were grouped as well.

The following tables (Tables 3.14 to 3.18) show the number of possible combinations of grouped HSU minus2-Rc/WP/plus2-Rc volumes. WPs are investigated in stratigraphic order, the AA first and carbonate aquifer last. Maps showing the locations of all detonations for grouped HSUs (vitric tuffs and tuff confining units), followed by separate maps showing saturated and unsaturated detonations for each WP HSU, are presented in Figures 3.32 to 3.37. The same color code is used for HSU identification, but incorporating green for the VTA, gold for the tuff confining unit, and light blue for the carbonate aquifers.

Tables are shown for all WP HSUs, since the minus2-Rc/WP/plus2-Rc volumes may have changed due to HSU groupings. No maps are shown for WPs in AA, UTCU, and TM-WTA because they would duplicate what was shown earlier in this section of the report. No maps are shown for the carbonate aquifer because the number of detonations in this group is small and information can be gleaned from maps shown earlier in this section.

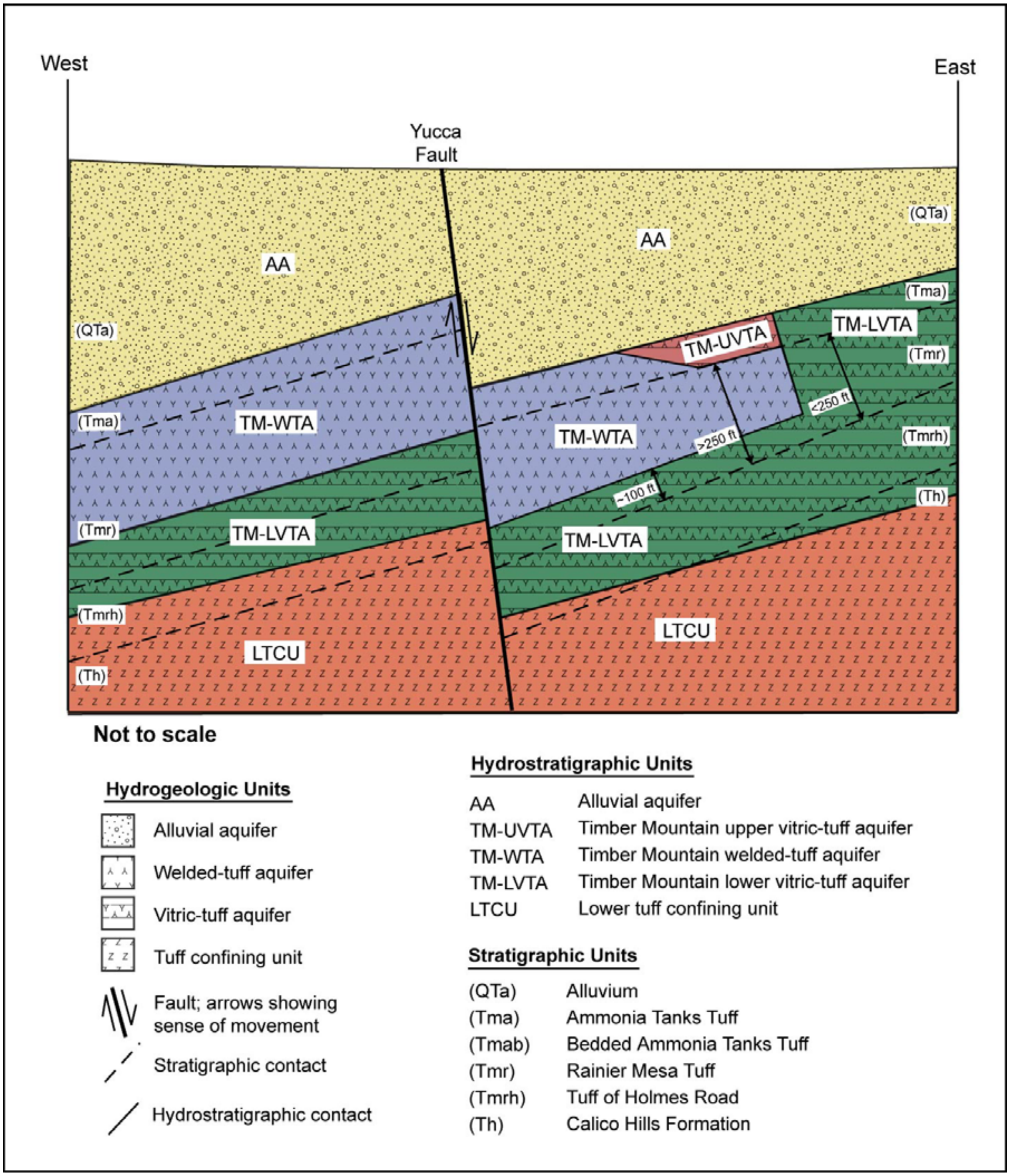

Figure 3.30 Schematic west-east cross section across Yucca Flat showing stratigraphic positioning of TM-UVTA, TM-TWA, and TM-LVTA (Figure 4-7 in Bechtel Nevada, 2006).

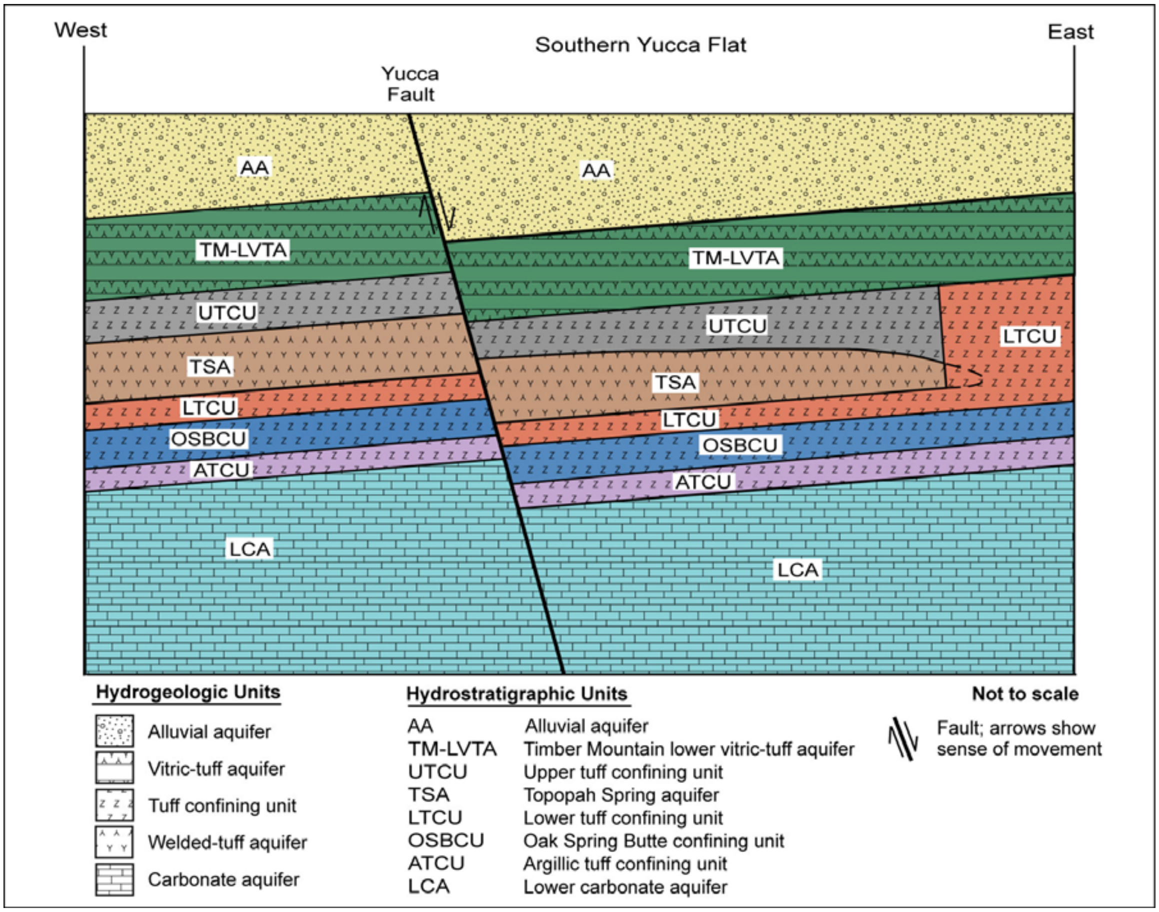

Figure 3.31 Schematic west-east cross section across Yucca Flat showing stratigraphic positioning of TM-LVTA and underlying tuff confining units (Figure 4-17 in Bechtel Nevada, 2006).

Table 3.14 HSU information for the 2-Rc volumes for detonations with WPs in the AA (with grouped HSUs).

ALL DETONATIONS	minus2Rc	415				
	WP	415				
	plus2Rc	275	39	86	10	5
SATURATED DETONATIONS	minus2Rc	28				
	WP	28				
	plus2Rc	7	3	16	2	
UNSATURATED DETONATIONS	minus2Rc	387				
	WP	387				
	plus2Rc	268	36	70	8	5

Legend (HSUs and HGUs are identified in Table 1.2)

AA
TM-WTA
VTA
TCU
MGCU
CA
UCCU
LCCU

Categories of detonations with WP in the AA (with grouped HSUs):

All detonations—5

Saturated detonations—4

Unsaturated detonations—5

Grouping of HSUs for detonations with WPs in AA are similar to information presented in Table 3.2, but reflect different information below the WP (plus2-Rc) due to grouping. The total for VTA is a sum of TM-UVTA and TM-LVTA; the total for TCU is the sum of the LTCU, OSBCU, and the ATCU; and the total for the CA is the sum of the LCA3 and the LCA. Distributions of detonations with WP in AA are identical to Figures 3.1, 3.2, and 3.3.

Table 3.15 HSU information for the 2-Rc volumes for detonations with WPs in the TM-WTA (with grouped HSUs).

ALL DETONATIONS	minus2Rc	22			1	4		
	WP	27						
	plus2Rc	2	15	5	1	1	2	1
SATURATED DETONATIONS	minus2Rc		6				1	
	WP		7					
	plus2Rc		4	2			1	
UNSATURATED DETONATIONS	minus2Rc	16			1	3		
	WP	20						
	plus2Rc	2	11	3	1	1	1	1

Legend (HSUs and HGUs are identified in Table 1.2)

AA
TM-WTA
VTA
TCU
MGCU
CA
UCCU
LCCU

Categories of detonations with WP in the TM-WTA (with grouped HSUs):

All detonations—7

Saturated detonations—3

Unsaturated detonations—7

The number of detonations with WP in TM-WTA is the same as shown in Table 3.5, but grouping of HSUs shows differences both above (minus2-Rc) and below the WP (plus2-Rc). The total for VTA is a sum of TM-UVTA and TM-LVTA, and the total for TCU is the sum of the LTCU, OSBCU, and the ATCU. Because the number of detonations with WP in the TM-WTA is the same, distributions of these detonations are identical to Figures 3.8, 3.9, and 3.10.

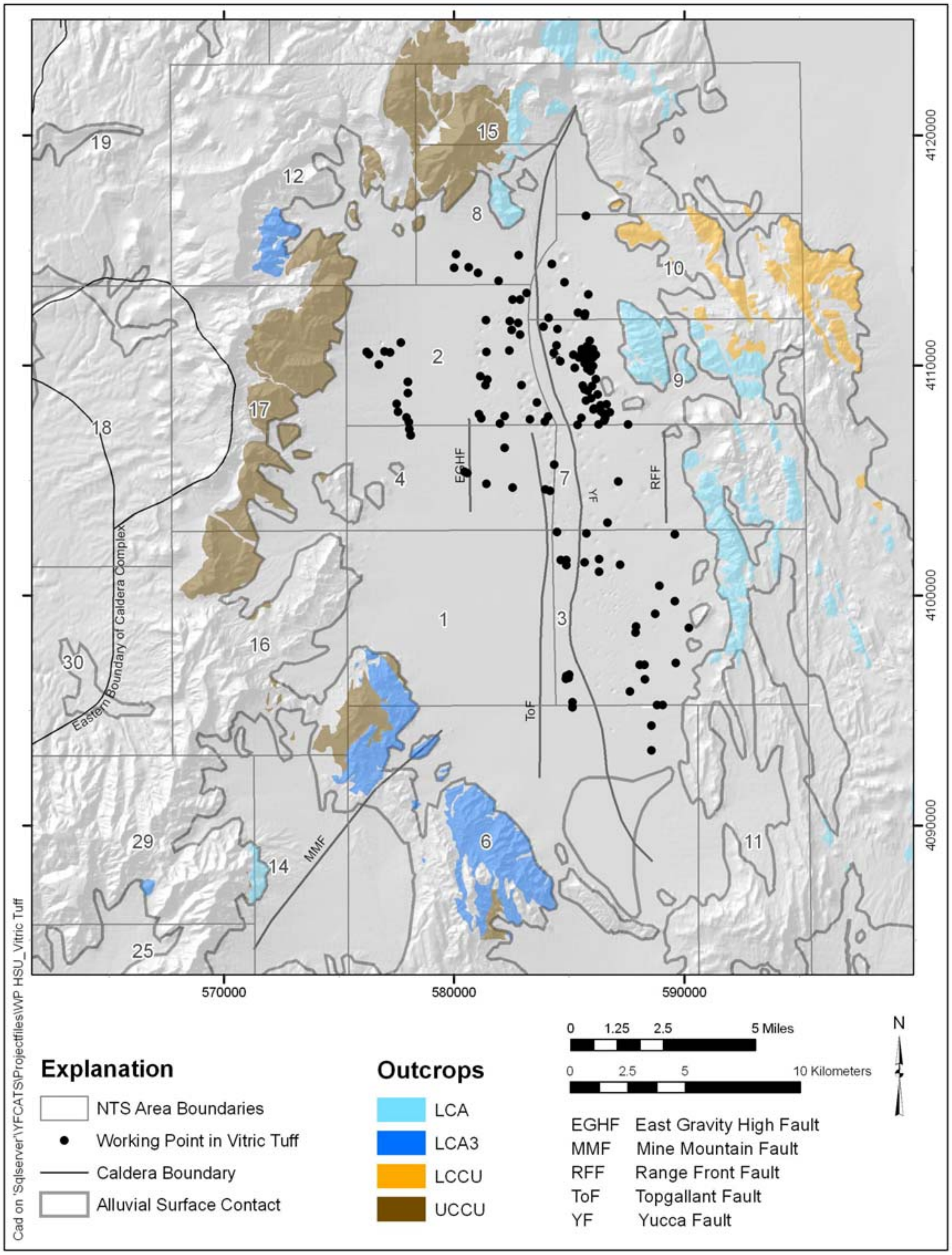

Figure 3.32 Locations of detonations with WP in grouped VTA.

Table 3.16 HSU information for the 2-Rc volumes for detonations with WPs in the VTA (with grouped HSUs).

ALL DETONATIONS	minus2Rc	72				13			59			
	WP	145										
	plus2Rc	14	27	24	7	2	3	9	1	18	29	11
SATURATED DETONATIONS	minus2Rc	22						4	11			
	WP	37										
	plus2Rc	3	7	12				4	1	2	6	2
UNSATURATED DETONATIONS	minus2Rc	50				10			48			
	WP	108										
	plus2Rc	11	20	12	7	2	3	5		16	23	9

Legend (HSUs and HGUs are identified in Table 1.2)

AA
TM-WTA
VTA
TCU
MGCU
CA
UCCU
LCCU

Categories of detonations with WP in the grouped VTA (with grouped HSUs):

All detonations—11

Saturated detonations—8

Unsaturated detonations—10

Detonations in the grouped VTA are located over the extent of Yucca Flat, with the exception of the southwest quarter (Figure 3.35). Detonations are located in western Areas 2 and 4 and east of the East Gravity High Fault (Areas 2, 3, 4, 7, 8, 9, and 10).

Saturated detonations in the grouped VTA are located in the western basin in Areas 2 and 4, and the faulted central part of the basin (Figure 3.36). More saturated detonations are located in northern than in southern Yucca Flat, where the depositional section is thinner and the water table is present in these units. Unsaturated detonations are generally located outside the central portion of Yucca Flat, where the saturated detonations are located. This includes western Areas 2 and 4; scattered in Areas 2 and 8; and east of the Topgallant and Yucca faults (Figure 3.37). Most of these detonations are located at least a bit east of the faults, indicating they are in thinner sections of the down-dropped tilted fault blocks.

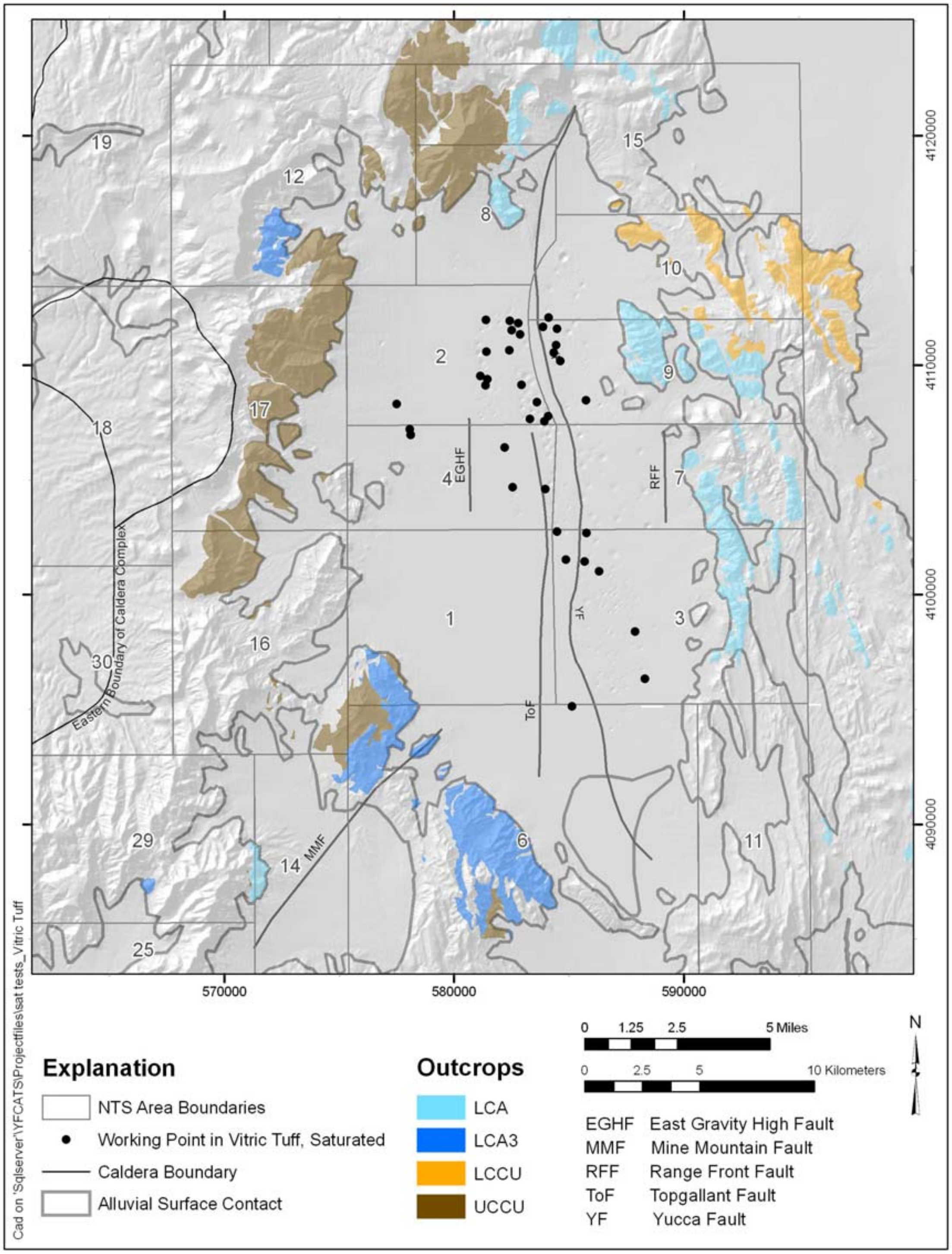

Figure 3.33 Locations of detonations with WP in saturated grouped VTA.

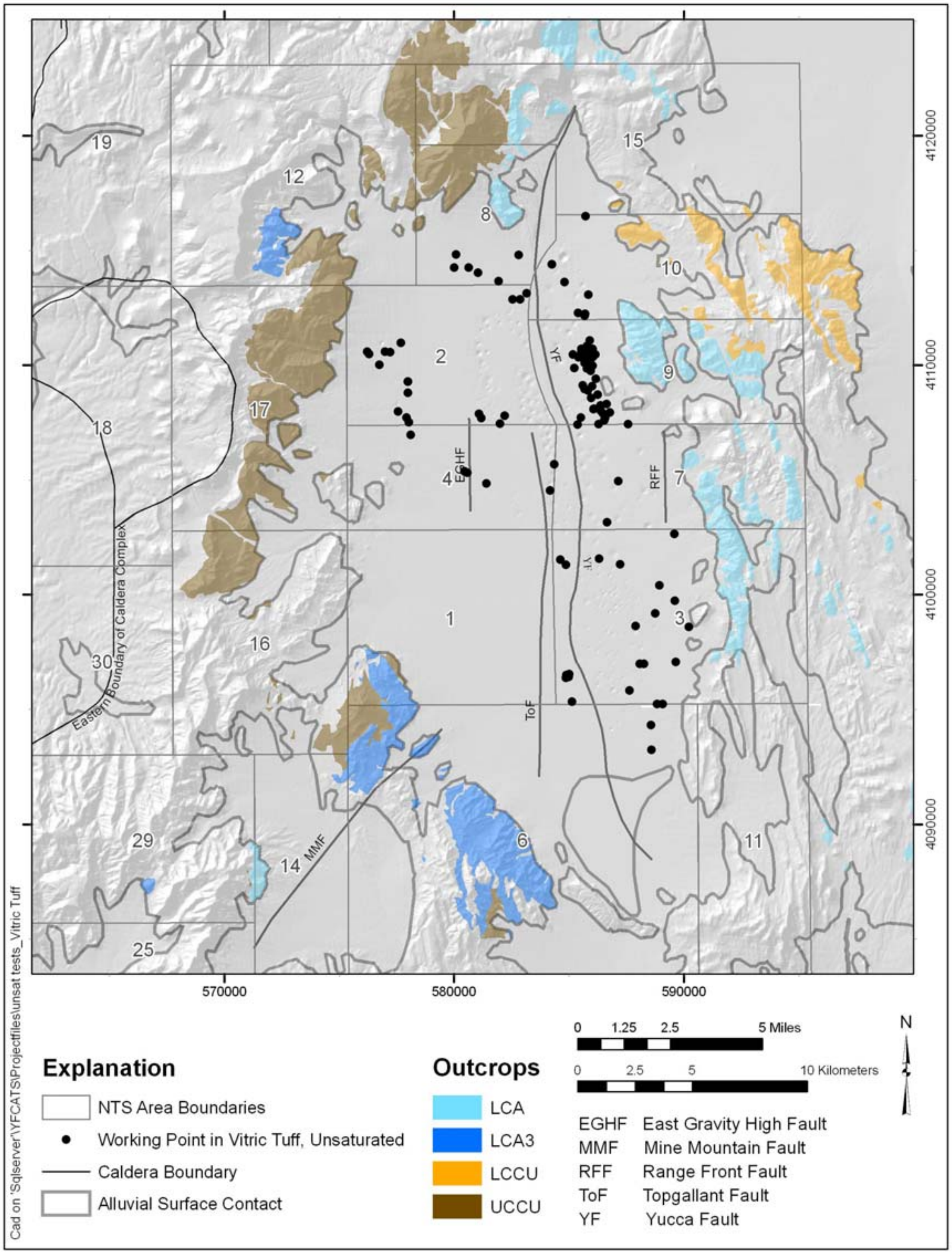

Figure 3.34 Locations of detonations with WP in unsaturated grouped VTA.

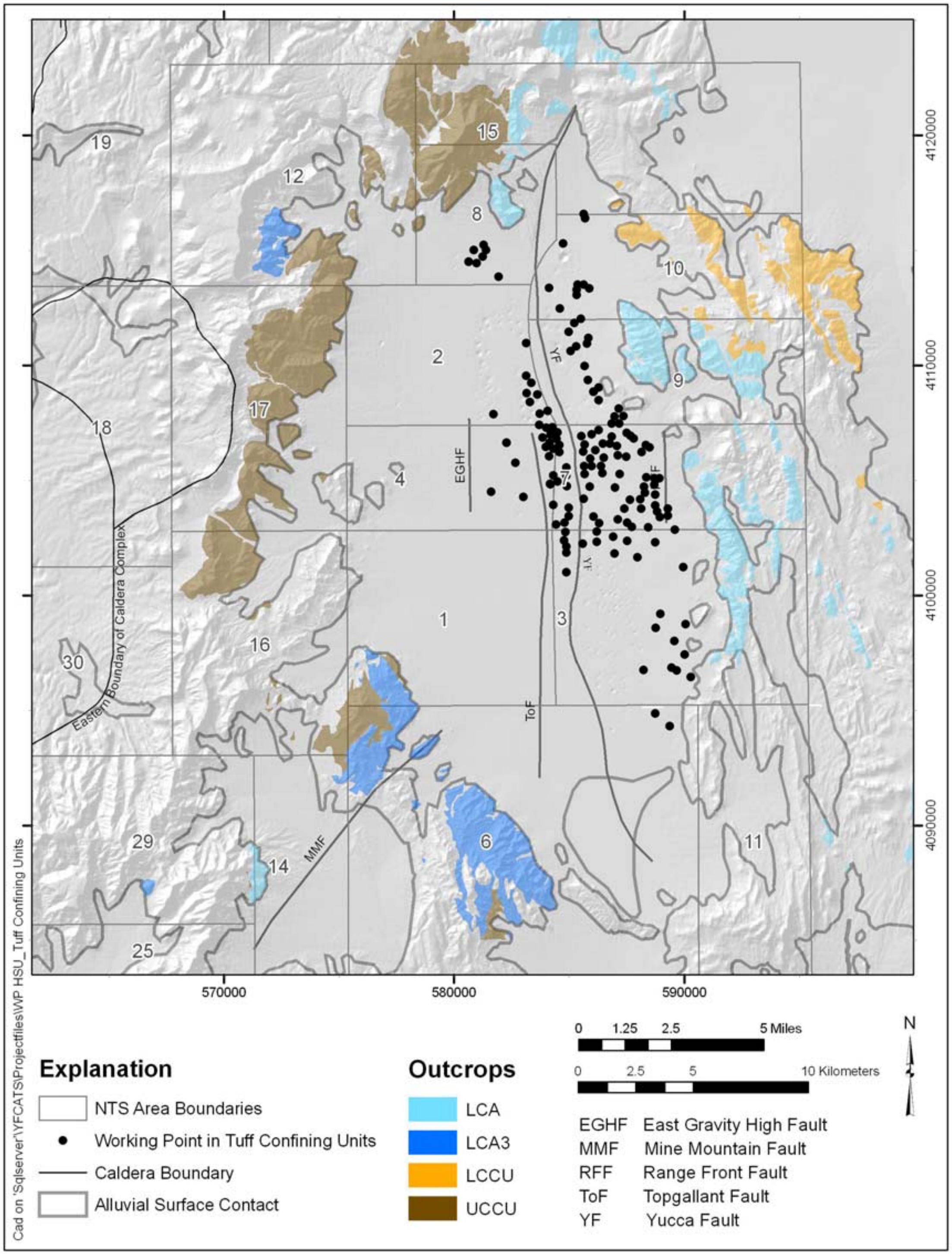

Figure 3.35 Locations of detonations with WP in grouped TCU.

Table 3.17 HSU information for the 2-Rc volumes for detonations with WPs in the TCU (with grouped HSUs).

ALL DETONATIONS	minus2Rc	4			14	48		85	
	WP	151							
	plus2Rc	1	1	2	14	40	8	76	9
SATURATED DETONATIONS	minus2Rc				12	18		65	
	WP	95							
	plus2Rc				12	14	4	57	8
UNSATURATED DETONATIONS	minus2Rc	4			2	30		20	
	WP	56							
	plus2Rc	1	1	2	2	26	4	19	1

Legend (HSUs and HGUs are identified in Table 1.2)

AA
TM-WTA
VTA
TCU
MGCU
CA
UCCU
LCCU

Categories of detonations with WP in the grouped TCU (with grouped HSUs):

All detonations—8

Saturated detonations—5

Unsaturated detonations—8

Grouped TCU (LTCU, OSBCU, and ATCU) detonations are located east of the East Gravity High Fault. Detonations mainly occur between the Topgallant and Yucca faults, and east of the Yucca Fault (Figure 3.31). Many of the detonations are located in Area 7 of central Yucca Flat. No detonations with WPs in the TCU occur in western Areas 2 and 4.

Saturated detonations mainly occur between the Topgallant and Yucca faults, and east of the Yucca Fault (Figure 3.32). Saturated detonations east of the Yucca Fault range in location—in the north (Areas 10 and 9), the detonations are located from the east side of the fault to about midway to the outcrops to the east; in the central portion (Area 7), the detonations span the distance between the Yucca and Range Front faults; and in the south (Area 3), the detonations span the distance from the Yucca Fault to mid Area 3. Unsaturated detonations occur east of the East Gravity High Fault, in a cluster in Area 8, and east of the Yucca Fault (Figure 3.33). The unsaturated detonations east of the Yucca Fault are at least halfway to the outcrop, indicating these detonations are in down-dropped, tilted fault blocks closer to the basin edge. These locations are identical, and also a bit east, of the unsaturated VTA detonation locations.

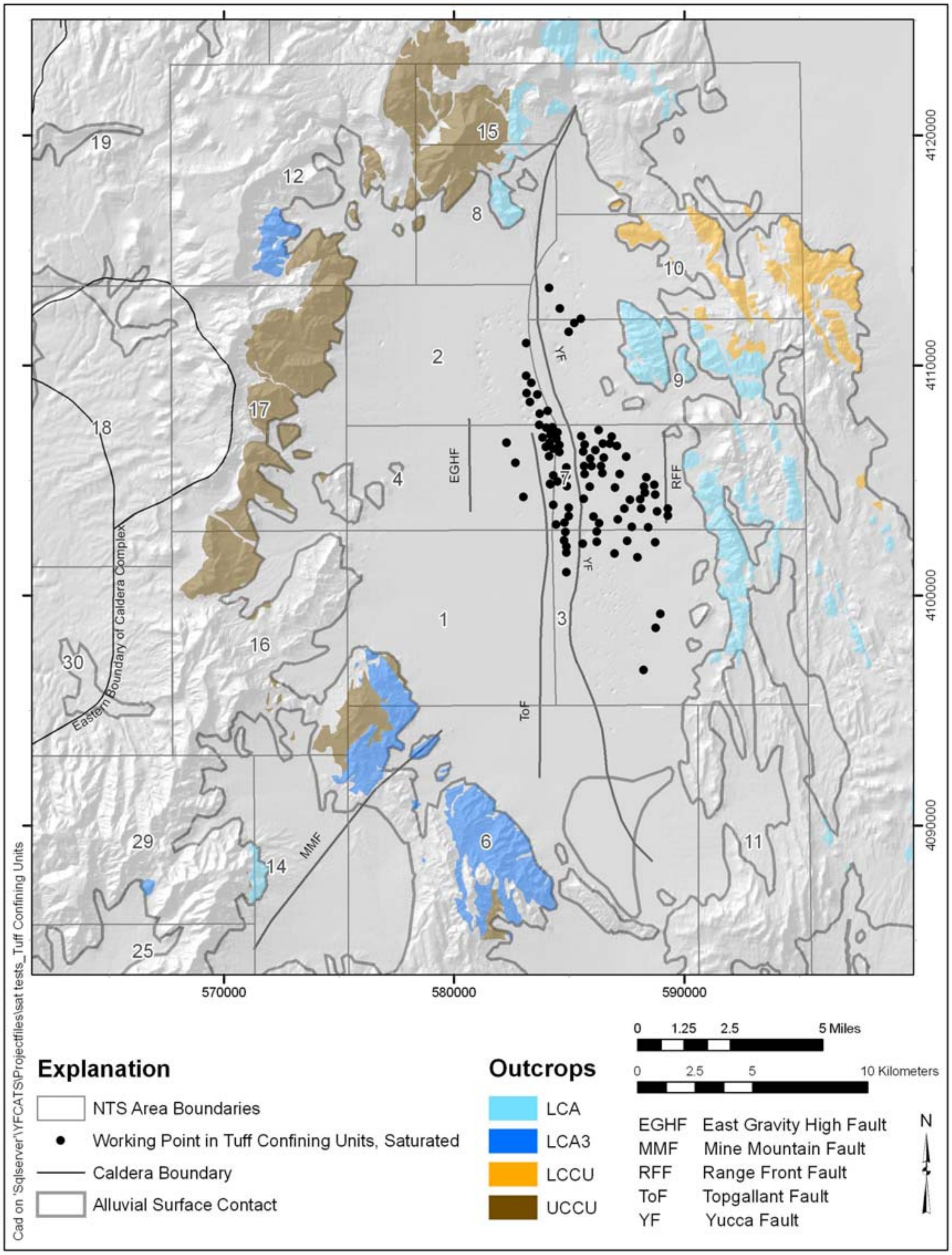

Figure 3.36 Locations of detonations with WP in saturated grouped TCU.

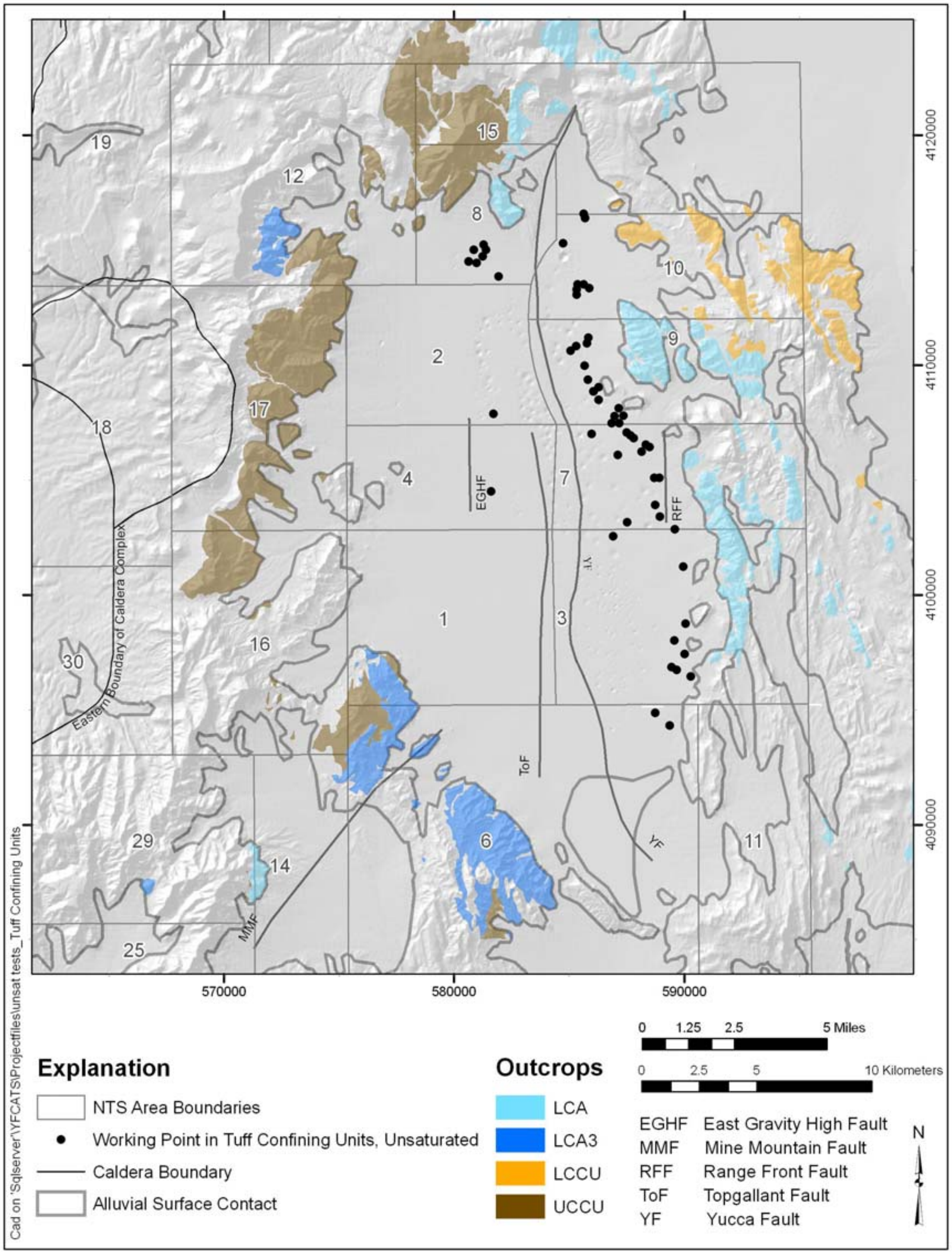

Figure 3.37 Locations of detonations with WP in unsaturated grouped TCU.

Table 3.18 HSU information for the 2-Rc volumes for detonations with WPs in the CA (with grouped HSUs).

ALL DETONATIONS	minus2Rc	1	1	1	1
	WP	4			
	plus2Rc	4			
SATURATED DETONATIONS	minus2Rc			1	
	WP	1			
	plus2Rc			1	
UNSATURATED DETONATIONS	minus2Rc	1	1		1
	WP	3			
	plus2Rc	2			1

Legend (HSUs and HGUs are identified in Table 1.2)

AA
TM-WTA
VTA
TCU
MGCU
CA
UCCU
LCCU

Categories of detonations with WP in grouped CA (with grouped HSUs):

All detonations—4

Saturated detonations—1

Unsaturated detonations—3

Grouped CA detonations are located in northern Yucca Flat, and shown in Figures 3.24, 3.25, 3.26, and 3.27. Due to the small total numbers of detonations, no additional figures are provided in this section.

3.5 Discussion of Grouped HSU Data

As shown in Table 3.19, the number of categories of detonations can be reduced when common HSUs are grouped, and at times, the number is reduced significantly. This seems reasonable when one considers the minus 2-Rc/WP/plus 2-Rc volume that is affected. The number of categories for all detonations in the AA declines from eight to five, where the combinations of HSUs at and above the WP stay the same, but combinations below the WP are reduced due to grouping HSUs. Categories for all detonations in TM-WTA stay the same, most likely because of the smaller numbers of detonations with WPs in TM-WTA, but also because this HSU is between the two grouped HSUs, and the cavity sizes are not affected by grouping HSUs. Categories for all detonations in the VTA were reduced significantly, as were those for all detonations in the TCU. This is because the grouped HSUs affect volumes both above and below the WP. Categories for the MGCU were not affected, since the volumes for these detonations occur entirely in the MGCU. Categories for all detonations in the CA did not change, most likely because of the smaller numbers of detonations with WPs in LCA3 and LCA, and the fact that the volume above the WP incorporated only one of the TCU subunits (LTCU). Thus the individual number and the grouped number remained the same.

Although the number of categories of detonations can be reduced when common HSUs are grouped, these categories will need to be reviewed by flow and transport modelers. As previously noted, flow and transport properties for the VTA should be similar. Flow properties for the TCU should also be similar. However, transport properties for the TCU will be different. The TCU was initially subdivided based on mineralogical differences that could be leveraged in transport models. If the range of Kds used for the LTCU, OSBCU, and ATCU are similar, then the categories determined from grouping altered tuffs is valid. If the ranges of Kds are unique, then the categories lose value.

Previously, when WP HSUs were evaluated, 45 detonations affected the carbonate aquifer. Four of these detonations had WPs in carbonate rocks, and 15 of the detonations were considered saturated. Grouping HSUs does not modify these numbers.

Table 3.19 Modified categories for WPs in HSUs.

Individual HSUs	Number of detonations with WP	Combinations determined for all detonations	Number of detonations with saturated WP	Combinations determined for saturated detonations	Number of detonations with unsaturated WPs	Combinations determined for unsaturated WPs
AA	415	8	28	5	387	8
TM-UVTA	17	3	5	2	12	2
UTCU	2	2	0	0	2	2
TM-WTA	27	7	8	3	20	7
TM-LVTA	128	16	32	9	96	15
LTCU	111	14	69	9	42	11
OSBCU	39	6	25	6	14	3
ATCU	1	1	1	1	0	0
MGCU	3	1	2	1	1	1
LCA3	1	1	0	0	1	1
LCA	3	3	1	1	2	2
Total	747	62	170	37	577	52
Grouped HSUs	**Number of detonations with WP**	**Combinations determined for all detonations**	**Number of detonations with saturated WP**	**Combinations determined for saturated detonations**	**Number of detonations with unsaturated WPs**	**Combinations determined for unsaturated WPs**
AA	415	5	28	4	387	5
TM-WTA	27	7	7	3	20	7
VTA	145	11	37	8	108	10
TCU	153	8	95	5	58	8
MGCU	3	1	2	1	1	1
CA	4	4	1	1	3	3
Total	747	36	170	22	577	34

4.0 Projection of Detonation Data to the Water Table

4.1 Unsaturated Detonations and Working Point/Water Table Relationships

Modeling radionuclide migration in groundwater seems straightforward when the volume of interest is completely below the regional water table. The initial partitioning of radionuclides under saturated conditions and radionuclide transport in groundwater is fairly well understood. However, when part or all of the 2Rc region is above the water table, assuming saturated conditions may not be accurate and may not be conservative in terms of radionuclide transport. The UGTA strategy for transport modeling in Frenchman Flat and Pahute Mesa CAUs assumed that all detonations were saturated (USDOE, 1997, USDOE, 1999a, USDOE, 1999b, and USDOE, 2001), and this seemed reasonable when the WPs were close to the water table, as occurred for Frenchman Flat and Pahute Mesa CAUs. However, only 170 of the 577 detonations in the Yucca Flat/Climax Mine CAU are actually "saturated." This definition of a saturated test, with a WP below or within 100 m of the water table, as shown in Figure 4.1, could permit a detonation up to 100 m above the water table to be modeled, assuming a completely saturated setting, where vadose zone modeling could be more appropriate.

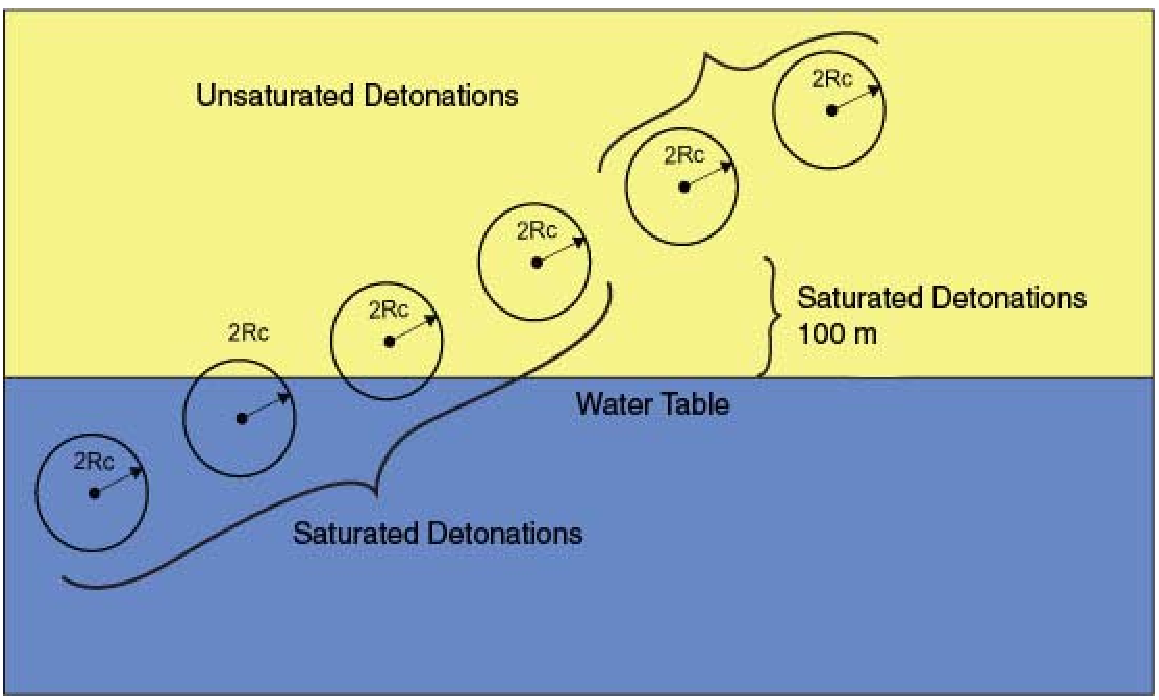

Figure 4.1 Schematic showing WP and water table relationships for saturated and unsaturated detonations.

There are several things to consider when determining the impact of saturation on a detonation. The radionuclide inventory is initially distributed within a volume approximately set to 2-Rc, with the cavity size related to the yield of each detonation (Pawloski, 1999). The inventory is partitioned in the melt glass, on the surface of the collapse rubble, and in the water (assuming saturation) of the 2-Rc volume. The UGTA Project has assumed that radionuclides move away from the 2-Rc volume via groundwater transport. i.e., the 2-Rc volume is saturated. If the water level is below this volume, gas phase transport may affect inventory partitioning and radionuclide release and migration processes, and assumptions used to date are not valid. Modeling at the CHESHIRE site has shown that in certain situations groundwater convection can move radionuclides up the chimney (above the 2-Rc distance) and into saturated permeable units well above the WP (Pawloski et al., 2001). If the chimney above the 2-Rc distance is not saturated, convection may not occur, limiting the volume affected by potential migration. We do not know the effect of having aquifers above the 2-Rc volume, i.e., will the aquifer connect to the collapse chimney? We do not know the impact if the volume of interest is separated from an overlying aquifer by a confining unit, i.e., can the aquifer contribute water to mobilize radionuclides?

In other words, we may not know or understand the impact of assuming that all detonations are saturated, nor do we know how to implement strategies that might deviate from this assumption. Given the large number of unsaturated detonations in the Yucca Flat/Climax Mine CAU, this lack of understanding will have a major effect on how the source term is calculated. In order to assess the effect of assuming all detonations are saturated, information for unsaturated detonations was evaluated to determine:

- What HSU was present at the water table directly under the unsaturated detonation WP.
- The distance from the unsaturated WP to the water table for the given detonation.
- The unsaturated distance from the ground surface to the WP (or the bottom of the collapse crater to the WP, if a crater exists).

This information is conceptually shown in Figures 4.2 and 4.3.

The first bullet above addresses calculating a source term in the host HSU and then lowering the source term to the water table. It would be technically incorrect to lower a WP and calculate a source term in the HSU at the water table. Unless the water-table HSU was similar to the original host HSU, we would expect different hydraulic and sorption properties, which would generate a source term completely different than that generated at the host HSU. Identifying the HSU at the water table will permit a comparison of release and transport capability.

Information about the second bullet will indicate if the detonation is a short or long distance above the water table (it does not investigate the HSUs involved over this distance). If an unsaturated detonation is a long distance above the water table, and no faults or other features are present nearby to create short-cut paths to aquifers, then a conclusion could be that this detonation may be eliminated from CAU contaminant boundary calculations.

Finally, the third bullet addresses the length of unsaturated material that recharge would have to infiltrate to reach the unsaturated WP before it could influence release and migration from the 2-Rc volume. If this distance is long, a conclusion could be that the unsaturated detonation is removed from the saturated zone and may not contribute to it; specifically, recharge and infiltration will not contribute to release of radionuclides from the unsaturated 2-Rc cavity volume.

The bulleted items above identify only the physical relationship between the surface, WP, and water table. This report does not discuss the possibility of vadose zone modeling, based on a CAU modeling strategy current in place.

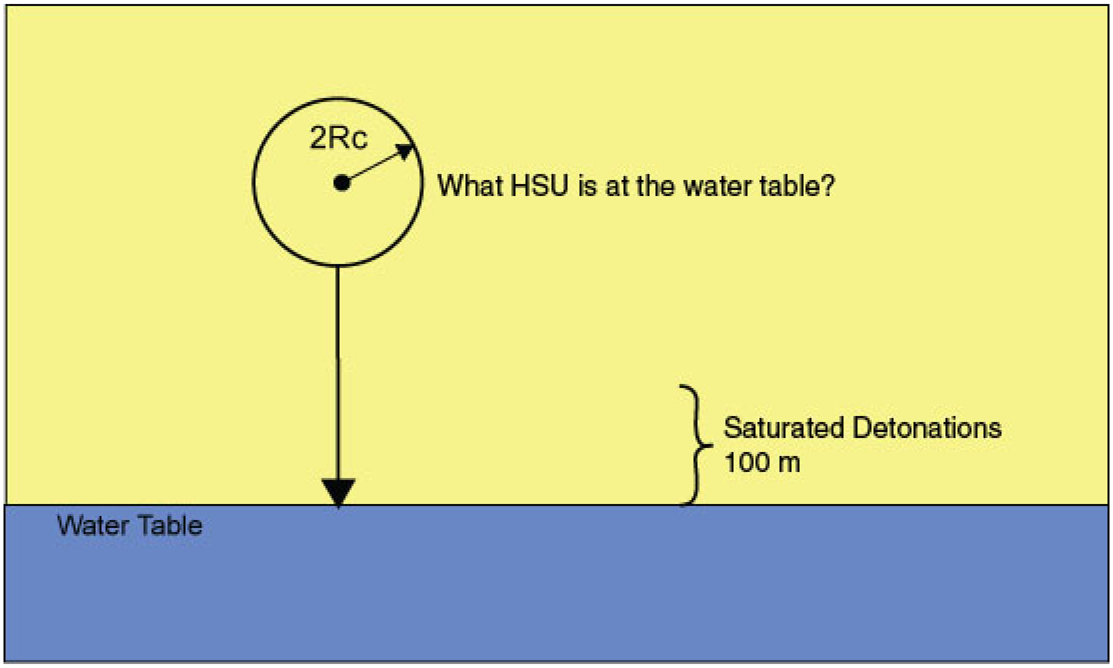

Figure 4.2 Schematic illustrating the concept of projecting unsaturated detonations to the HSU at the water table.

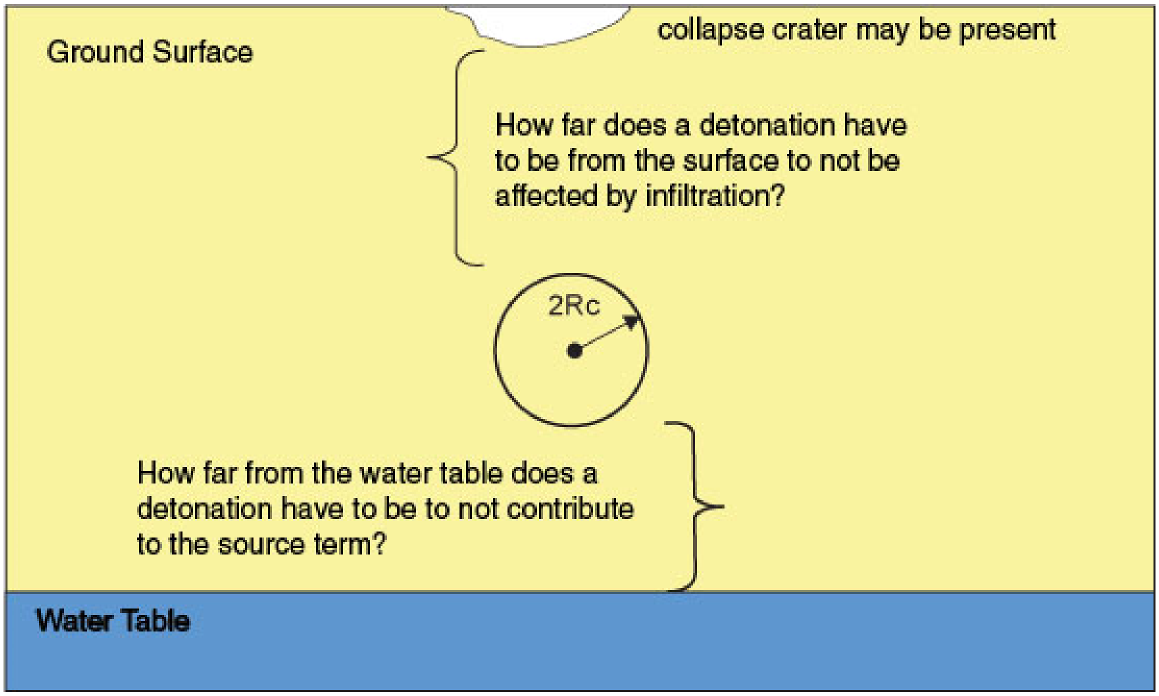

Figure 4.3 Schematic identifying important features to consider for including unsaturated detonations in radionuclide transport studies, when including the distance from ground surface to WP and distance from WP to water table.

4.2 Projecting Unsaturated Detonations to the Water Table

Appendix C shows information for 577 unsaturated detonations (WP greater than 100 m above the water table). Seventy-eight detonations with WP between the water table and 100 m of the water table are included in a separate section at the bottom of the table for informational purposes, however, these detonations are not included in the following figures. The Appendix C table is similar to the one in Appendix B but also identifies the HSU at the water table, or the location of the WP if it were translated directly down to the water table. The distance from the unsaturated WP to the water table is shown in cavity radii for each detonation. Also included is the distance from the ground surface (or the bottom of the collapse crater, if one exists) to the WP. The table is sorted by HSU at the water table; each group of HSUs at the water table is sorted by true host WP HSU. For example, all unsaturated detonations that project to the LCA are grouped together. Within this LCA group, detonations with true WPs located in the AA will come before WPs in the LCA, then the LTCU, then the OSBCU, etc.

Figures 4.4 to 4.11 show the locations of unsaturated detonation WPs, projected to the water table, with the distance from the WP to the HSU at the water table indicated in cavity radii. Blue dots show the locations of saturated detonations that have WPs located in the same HSU. Thus, Figure 4.4 shows any unsaturated detonation that when projected to the water table is located in the AA. Also on the figure are the locations of saturated detonations located in the AA. The subsequent figures show the same information for the TM-UVTA, TM-WTA, TM-LVTA, LTCU, OSBCU, MGCU, and carbonate rocks (LCA3 and LCA).

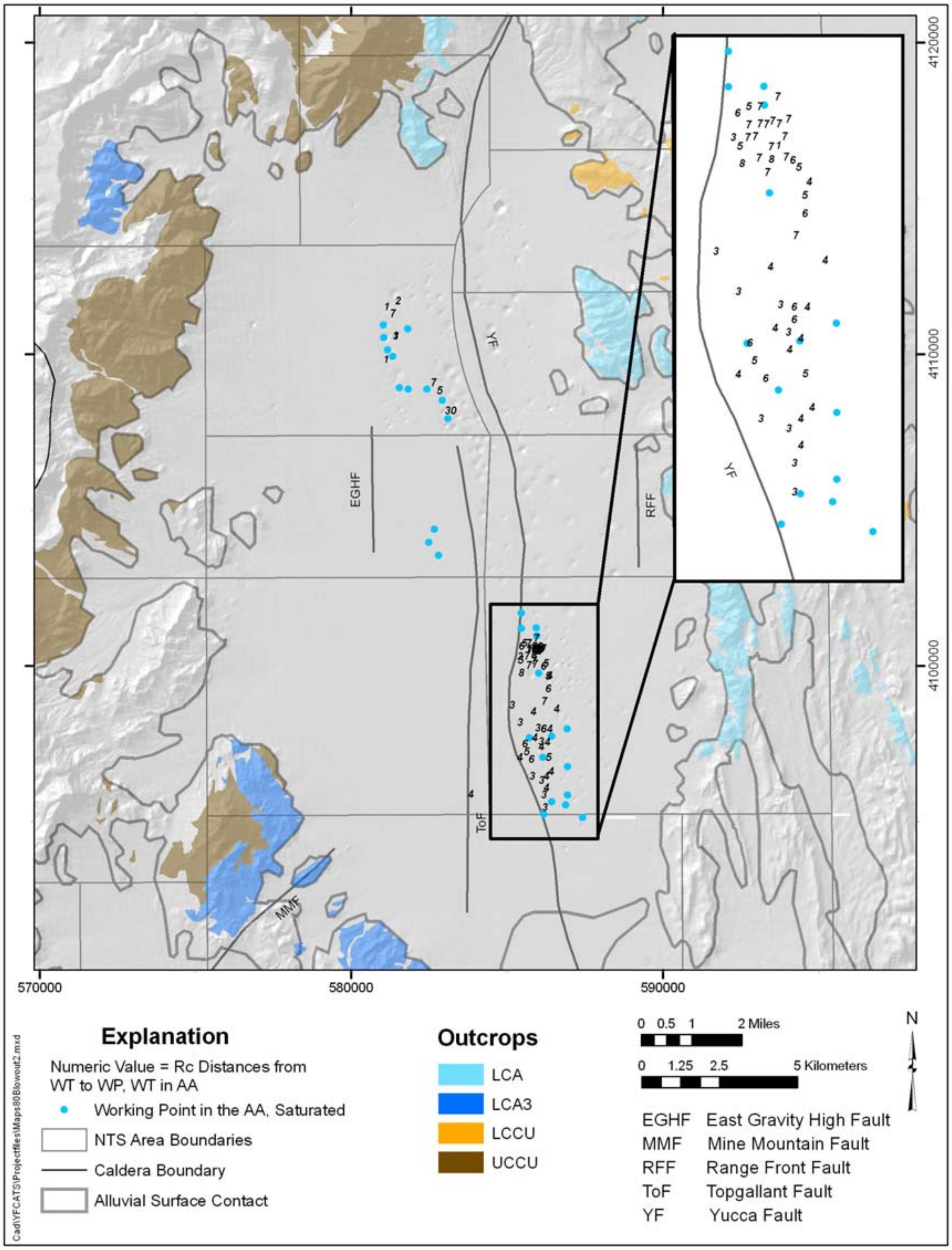

Figure 4.4 Numeric values show locations of unsaturated detonations that when projected to the water table would be located in the AA (numeric value is distance from WP to water table, in cavity radii). Blue dots are saturated detonations with WPs in the AA.

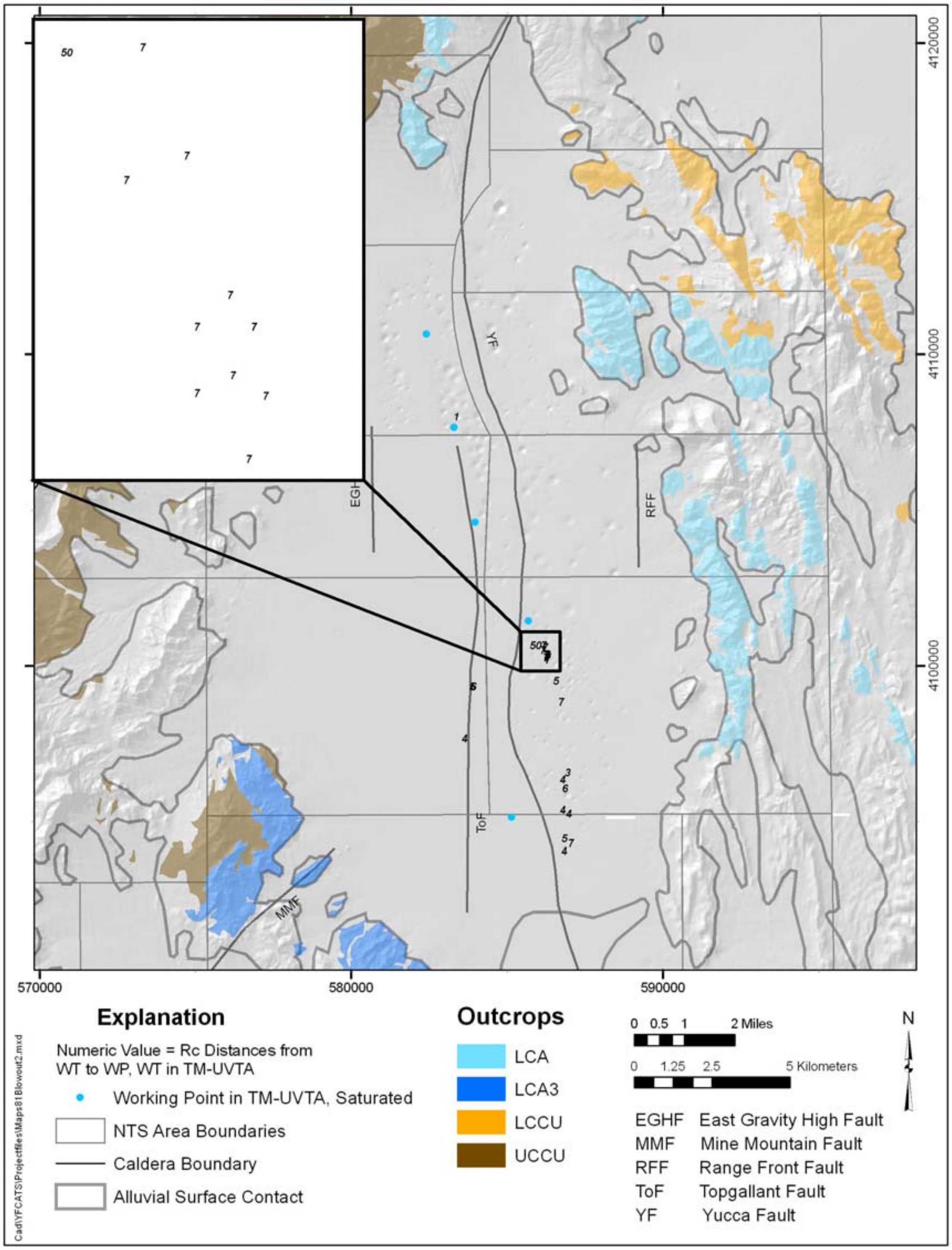

Figure 4.5 Numeric values show locations of unsaturated detonations that when projected to the water table would be located in the TM-UVTA (numeric value is distance from WP to water table, in cavity radii). Blue dots are saturated detonations with WPs in the TM-UVTA.

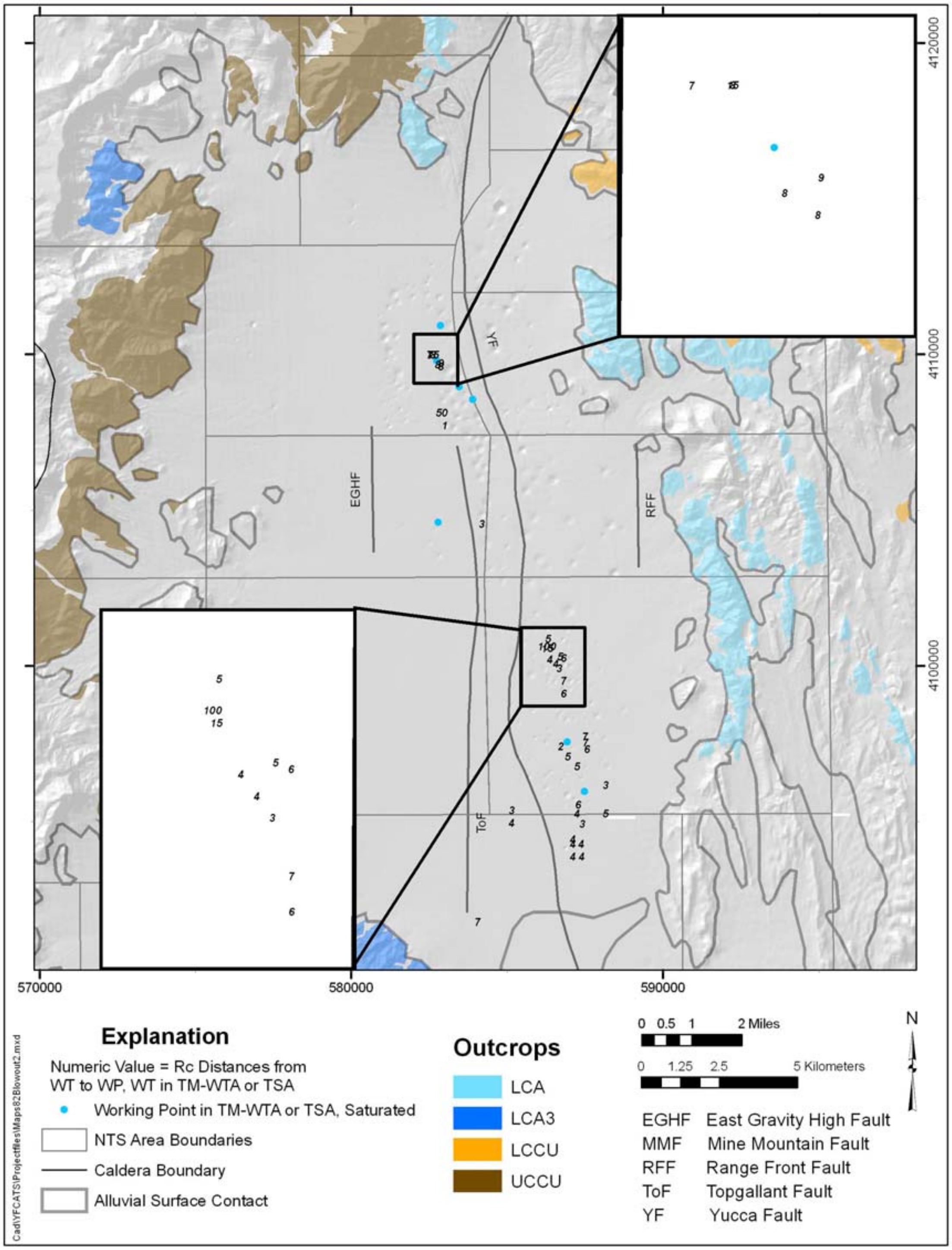

Figure 4.6 Numeric values show locations of unsaturated detonations that when projected to the water table would be located in the TM-WTA (numeric value is distance from WP to water table, in cavity radii). Blue dots are saturated detonations with WPs in the TM-WTA.

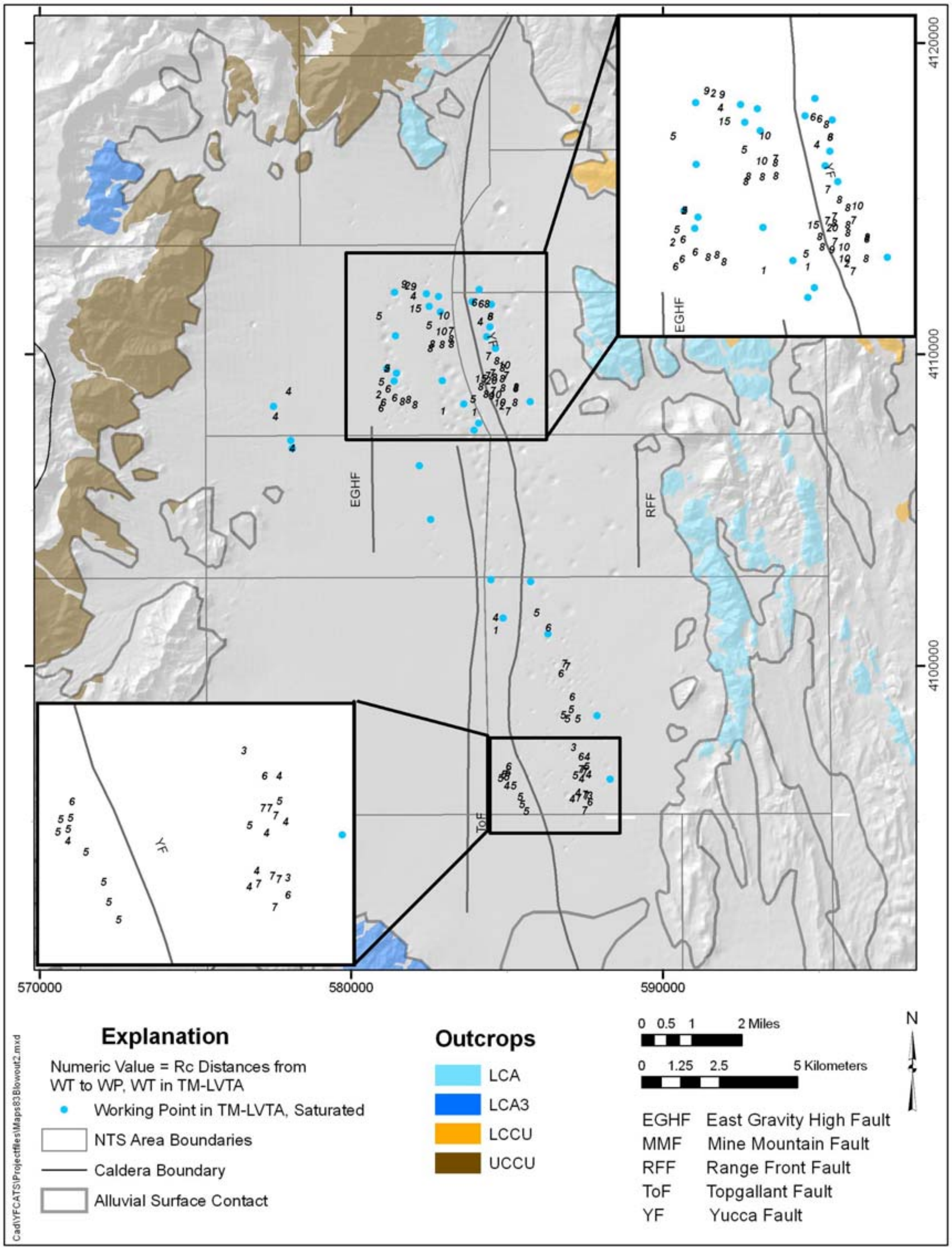

Figure 4.7 Numeric values show locations of unsaturated detonations that when projected to the water table would be located in the TM-LVTA (numeric value is distance from WP to water table, in cavity radii). Blue dots are saturated detonations with WPs in the TM-LVTA.

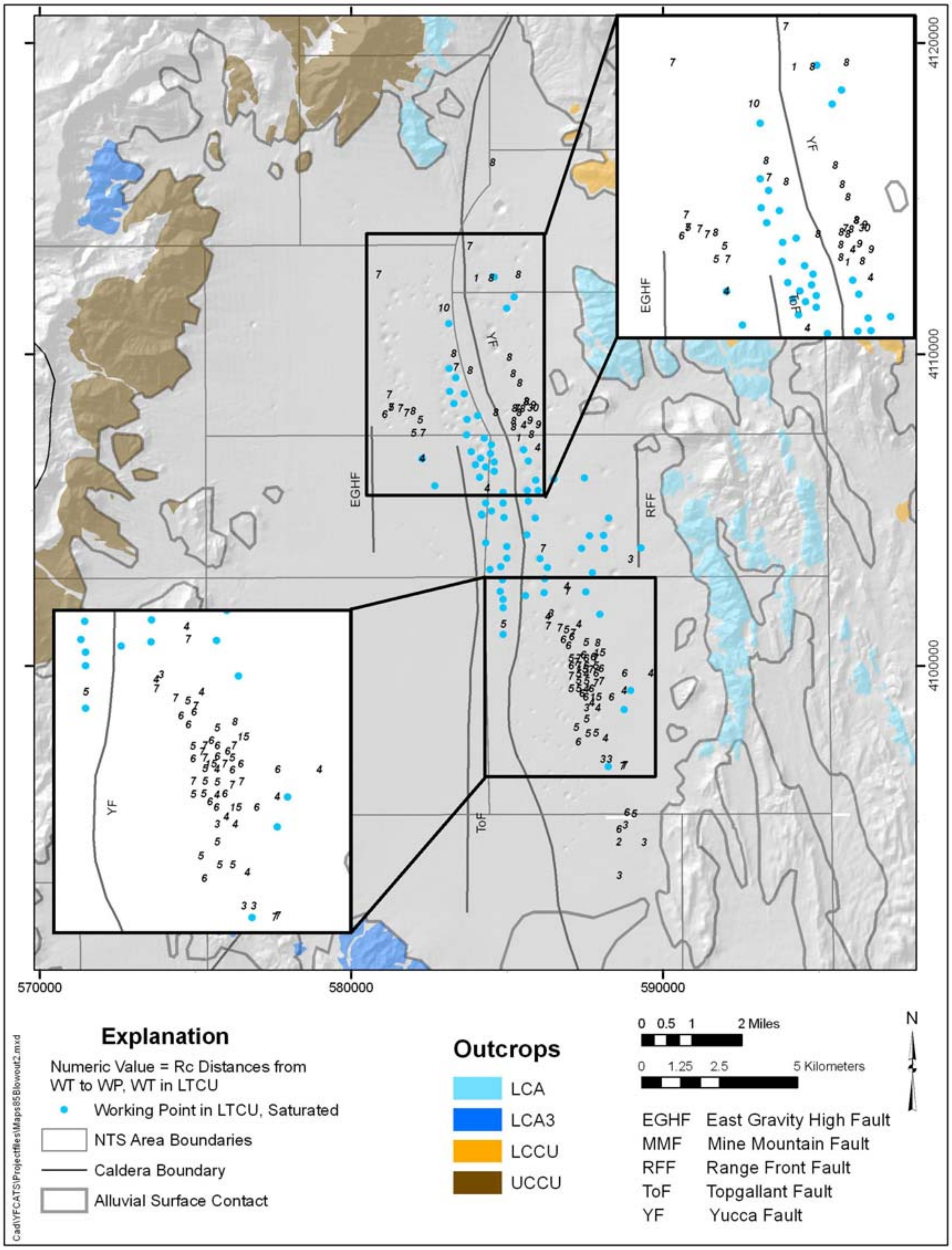

Figure 4.8 Numeric values show locations of unsaturated detonations that when projected to the water table would be located in the LTCU (numeric value is distance from WP to water table, in cavity radii). Blue dots are saturated detonations with WPs in the LTCU.

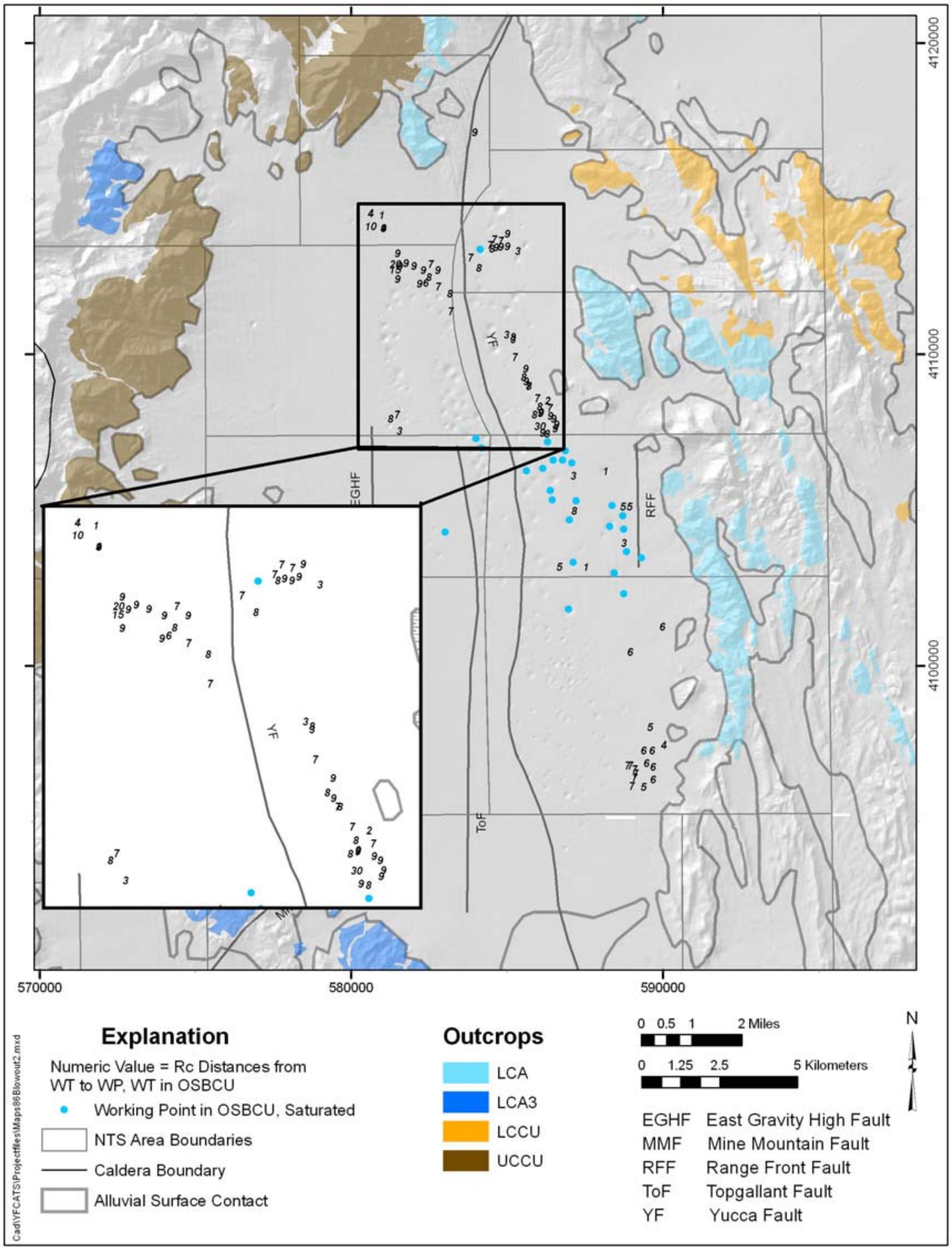

Figure 4.9 Numeric values show locations of unsaturated detonations that when projected to the water table would be located in the OSBCU (numeric value is distance from WP to water table, in cavity radii). Blue dots are saturated detonations with WPs in the OSBCU.

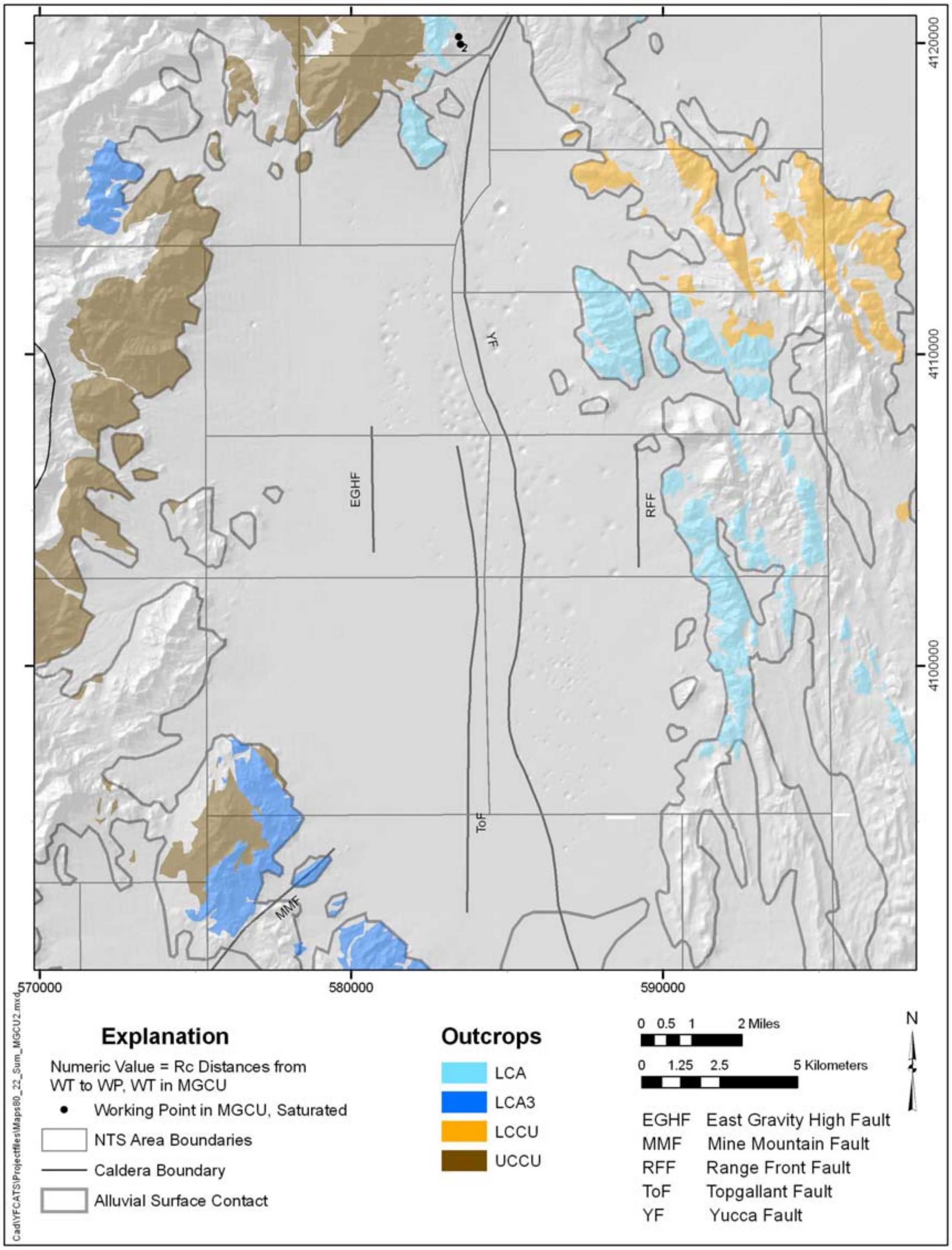

Figure 4.10 Numeric values show locations of unsaturated detonations that when projected to the water table would be located in the MGCU (numeric value is distance from WP to water table, in cavity radii). Blue dots are saturated detonations with WPs in the MGCU. Detonations are located at the top of the figure.

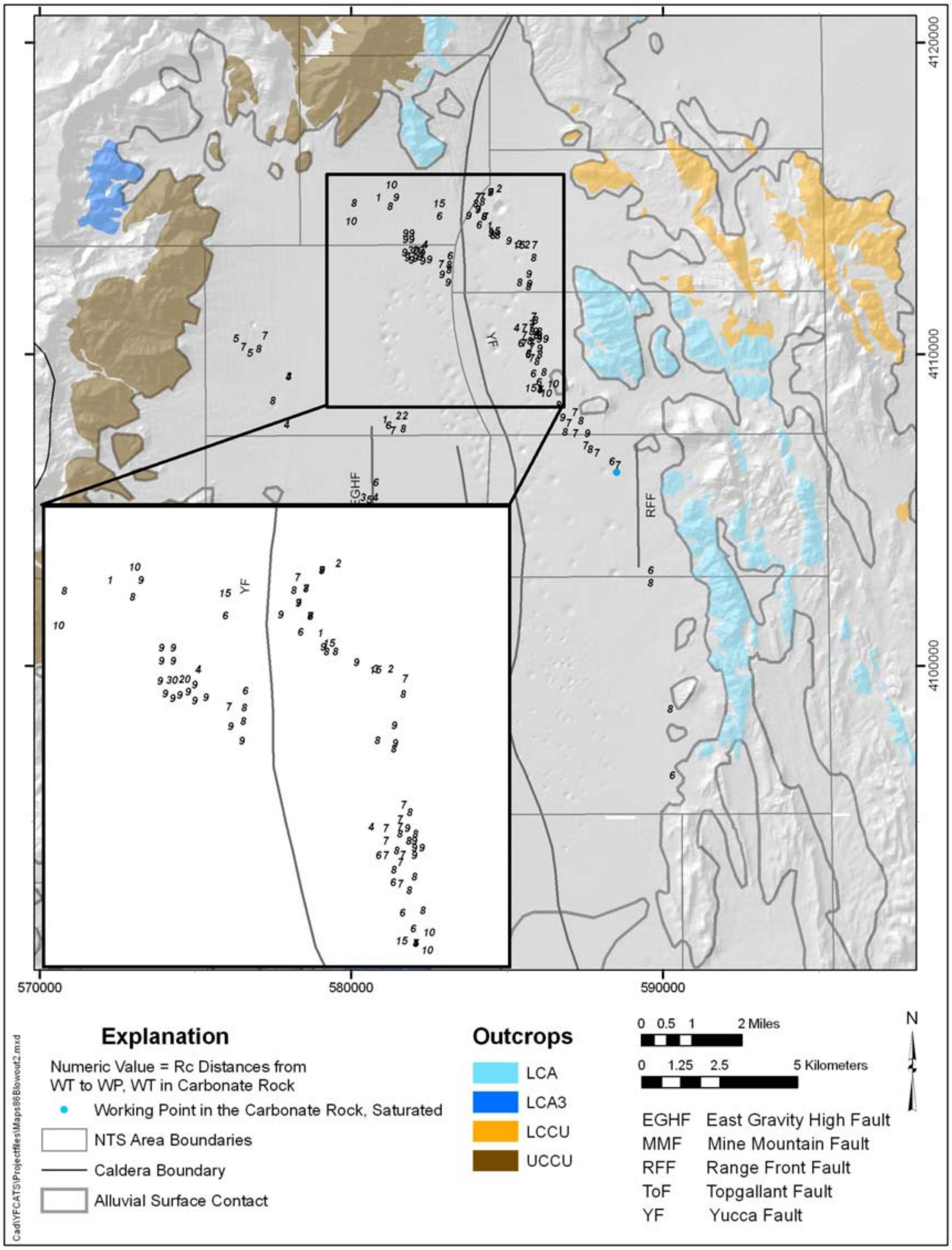

Figure 4.11 Numeric values show locations of unsaturated detonations that when projected to the water table would be located in carbonate rocks (numeric value is distance from WP to water table, in cavity radii). Blue dots are saturated detonations with WPs in carbonate rocks (LCA3 and LCA).

4.3 Discussion of Projecting Unsaturated Working Points to the Water Table

Table 4.1 summarizes the number of unsaturated WPs that when projected vertically to the water table would be present in various HSUs. About 20% of all unsaturated detonations would project into each the LTCU and the LCA, about 18% would project into the TM-LVTA, about 14% would project into the OSBCU, and about 11% would project into the AA. The remaining projections are all under 10% each. About 75% of the unsaturated detonations would project into HSUs above the regional carbonate aquifer. About 35% of the unsaturated detonations would project into the tuff confining unit above the regional carbonate aquifer. It is important to note that about 23% of the unsaturated detonations would project directly into the regional carbonate aquifer, if the unsaturated WP is translated directly down to the water table. The number of unsaturated detonations that would affect the carbonate aquifer from projection (133) is much larger than the number of unsaturated detonations (30) where the 2-Rc volume incorporates any of the carbonate aquifer (Chapter 3.3).

Table 4.2 expands on information presented in Table 4.1 and shows a comparison of the number of detonations at the original HSU that hosts the unsaturated WP and the projected HSUs at the water table. Most host HSUs changed when the projection was performed. For example, 387 unsaturated WPs were hosted in the AA. If these 387 detonations were projected to the water table, then 65 would occur in the AA, 26 in the TM-UVTA, 3 in the UTCU, 35 in the TM-WTA, 87 in the TM-LVTA, 85 in the LTCU, 39 in the OSBCU, 2 in the ATCU, 4 in the LCA3, 40 in the LCA, and 1 in the UCCU. Another way to read the table is to see that there were 65 unsaturated detonations projected to the AA at the water table, and all 65 had original unsaturated WPs hosted in the AA. Of the 133 unsaturated detonations that project to the carbonate aquifer at the water table, 44 of the WPs were originally hosted in the AA, 1 in the TM-WTA, 54 in the TM-LVTA, 21 in the LTCU, 11 in the OSBCU, and 2 in the LCA.

Table 4.1 HSU when the unsaturated WP is projected to the water table.

Model Name	AA	TM-UVTA	UTCU	TM-WTA	TM-LVTA	LTCU	OSBCU	ATCU	MGCU	LCA3	LCA	UCCU	LCCU
Base Model (total % of unsaturated detonations)	65 (11%)	26 (4%)	3 (<1%)	38 (6%)	101 (18%)	113 (20%)	84 (14%)	5 (<1%)	1 (<1%)	17 (3%)	116 (20%)	5 (<1%)	3 (<1%)

Table 4.2 WP HSU projected to the water table, compared to the original host HSU.

HSU at Water Table	AA 387	TM-UVTA 12	UTCU 2	TM-WTA 20	TM-LVTA 96	LTCU 42	OSBCU 14	ATCU	MGCU 1	LCA3 1	LCA 2	UCCU	LCCU
AA - 65	65												
TM-UVTA - 26	26												
UTCU – 3	3												
TM-WTA – 38	35	2		1									
TM-LVTA – 101	87	6		5	3								
LTCU – 113	85	3	1	6	14	4							
OSBCU – 84	39	1	1	7	20	13	3						
ATCU – 5	2				1	2							
MGCU – 1									1				
LCA3 – 17	4			1	11	1							
LCA – 116	40				43	20	11				2		
UCCU – 5	1				3					1			
LCCU – 3					1	2							
Change from host HSU to projected HSU (%)	83	100	100	95	97	90	78		0	100	0		

4.4 Comparison of Uncertainty in HSU Assignments between the Base Hydrostratigraphic Model and Alternates

Bechtel Nevada geologists constructed a structural model and hydrostratigraphic system for the Yucca Flat/Climax Mine CAU (Bechtel Nevada, 2006), which has been identified as the base model. To address the complex geologic structure and non-unique aspects of different three-dimensional interpretations within the base model, they also developed five alternative interpretations for portions of the base model. Each alternative was bound by all the data and the same interpretation methods. These alternative models include:

- Contiguous UCCU in Southwestern Yucca Flat—The base model assumes that the UCCU is intermittent in southwestern Yucca Flat. Magnetotelluric data suggest that the area is underlain by thick, highly resistive carbonate rocks, and that the siliciclastic rocks of the UCCU do not form a thick continuous sheet of clastic confining unit. Structural relationships due to thrust faulting make interpreting data complex. The alternative model makes the UCCU contiguous over the southwestern side of Yucca Flat. This interpretation can have potential significance to groundwater flow, particularly flow out of the basin to the southwest.

- Fault Juxtaposition—This model assumes that faults naturally juxtapose various HSUs. However, the locations, orientations, and amounts of displacement are not precisely constrained. In this alternative model, a volcanic aquifer (TM-WTA or TM-LVTA) was positioned against the LCA by either increasing fault displacements of thinning underlying confining units (while still conforming to drill hole data). Changes for this alternative model were made in testing areas and below the water table. This alternative permits more cases where an overlying aquifer will be located adjacent to the carbonate aquifer.

- Hydrologic Barrier in Northern Yucca Flat—In the base model, groundwater flow from the north is limited by the location of the LCCU, UCCU, and MGCU. The alternative model further restricts flow by raising an anticline of LCCU to the water table on the east side of the Climax Stock and placing UCCU near the Tippinip Fault on the west.

- Partial Zeolitization—In north-central Yucca Flat, a zone of partial zeolitization (<30wt% zeolite) has been recognized above the zone of pervasive zeolitization (>30 wt%). This partial zeolitization zone is gradational and hard to identify. However, the presence of zeolites, even in small amounts, can affect transport properties. An alternative model was created to show the partial zeolitization zone in areas 2 and 9. This interpretation, which adds an additional zone of (partial) zeolitization, can reduce radionuclide migration by permitting sorption where the new zone is present.

- CP Thrust—In the base model, the eastern extent of the CP Thrust is coincident with the Carpetbag–Topgallant faults. The alternative model shifts the eastern extent of the thrust to the Yucca Fault in the northern section of Yucca Flat, providing more extensive UCCU in the subsurface in this area. This change could have a significant hydrologic effect, potentially limiting influx of groundwater into Yucca Flat from the north and restricting it to under the UCCU.

Table 4.3 shows the HSU for the base and alternative models when the unsaturated WP is projected to the water table. Base model information in Table 4.3 is the same as that presented in Table 4.1. It is interesting to note that for three alternatives, there is not much change of HSU in the various models when the unsaturated WP is projected to the water table. The alternatitves—contiguous UCCU, fault juxtaposition, and hydrologic barrier—show only minor changes. However, the partial zeolitization alternative shows a decrease in WPs in the TM-LVTA and the number of detonations in the table does not add up to 577 as all other models do, because the alternative adds a HSU that is not shown (partial zeolitization). This alternative affects HSUs stratigraphically near the new zone of partial zeolotization. With the exception of the decrease of WPs in TM-WTA, TM-LVTA, and LTCU, and associated increase in the partial zeolitization group, other WP HSUs remain the same. Another significant change is the CP thrust alternative, which affected WPs projected to the LCA3 and the LCA (and 3 in the OSBCU). Many more WPs were projected to be in the LCA3 because moving the CP thrust fault to the east extended the range of the LCA3 east, and any detonation west of the Yucca Fault is now projected into the LCA3 instead of the LCA (except for 3 now in the OSBCU).

Only minor changes are seen in HSUs when unsaturated WPs are projected to the water table for three alternatives, and significant changes are seen for the other two. The conclusion that can be made is that, in the testing areas:

- Changes in the contiguous UCCU alternative model occur below the water table and don’t affect the region between the WP and the water table.
- Changes in the fault juxtaposition alternative model do not affect WP projections because WPs are generally located at a distance from faults for containment reasons.
- Changes in the hydrologic barrier alternative model do no affect WP projections because this region is distant from WPs.
- Changes in the partial zeolitization alternative model affect detonations with WPs in this newly defined unit and reduce the number of WPs in nearby HSUs.
- Changes in the CP thrust alternative model affect detonations west of Yucca Fault because the LCA3, stratigraphically above the LCA, is extended east.

Note that all of these changes are based only on three-dimensional hydrostratigraphic models and do not account for differences that may be derived from flow and transport models.

Table 4.3 HSU for base and alternative models when the unsaturated WP is projected to the water table.

Model Name	AA	TM-UVTA	UTCU	TM-WTA	TM-LVTA	LTCU	OSBCU	ATCU	MGCU	LCA3	LCA	UCCU	LCCU
Base Model	65	26	3	38	101	113	84	5	1	17	116	5	3
Alternate-Contiguous UCCU	65	26	3	38	101	113	84	5	1	17	116	5	3
Alternate-Fault Juxtaposition	65	26	3	42	100	111	85	4	1	17	115	5	3
Alternate-Hydrologic Barrier	65	26	3	38	101	113	84	5	1	17	116	5	3
Alternate-Partial Zeolitization	62	26	3	34	74	110	84	5	1	17	116	5	3
Alternate-CP Thrust	65	26	3	38	101	113	87	5	1	51	80	5	2

5.0 Analysis of Detonation Data for Special Cases

5.1 Simultaneous Detonations

Yucca Flat is one of two CAUs at the NTS that hosted simultaneous detonations; Rainier Mesa is the other. Simultaneous detonations are defined (USDOE, 2000b) as either:

- Simultaneous, separate holes—a single detonation, or two or more detonations, conducted within an area delineated by a circle having a diameter of two kilometers and conducted within a total period of time not to exceed 0.1 second; or
- Simultaneous, same hole—two or more detonations occurring in the same hole and conducted within a total period of time not to exceed 0.1 second.

There were 40 simultaneous tests in separate holes, totaling 103 detonations in the Yucca Flat/Climax Mine CAU (Appendix A). As shown in Figure 5.1, they were located in Areas 2, 3, 6, 9, and 10. The detonations occurred from 1963 to 1988, with most of them occurring from 1963 to 1977. In terms of evaluating radionuclide migration, simultaneous detonations in separate holes simply require the appropriate source to be placed in the proper hole and released at the correct zero time. As such, they are treated no differently from any other detonation in the Yucca Flat/Climax Mine CAU.

Describing simultaneous tests in the same hole using information in USDOE, 2000b becomes complicated due to the timing issue. There were 22 tests in 21 holes, consisting of 47 detonations, that are considered to be simultaneous, same hole by the definition above. As shown in Figure 5.2, these simultaneous, same hole detonations were located in Areas 1, 2, 3, 4, 8, 9, and 10. They occurred from 1968 to 1992, with most of them occurring during the 1960s and 1970s. Information from these detonations was evaluated to determine how the WPs and 2-Rc volumes related to each other in the same hole, in order to develop appropriate conceptual models to distribute radionuclides to initialize migration simulations. Table 5.1 summarizes selected information for these detonations.

Two other tests need to be included in this simultaneous, same hole detonation evaluation because they occurred before but in the same emplacement hole with simultaneous, same holes tests included in Table 5.1, but outside of the time portion of the definition above. Crew, located in U2db with Crew-2nd and Crew-3rd, and Flax-Source, located in U2dj with Flax-Backup and Flax-Test, were evaluated to determine WP and 2Rc configurations in the same hole, for radionuclide migrations purposes only. Rhyolite and Nightingale count as 2 tests (2 detonations) in the same hole, each occurring simultaneously with the other test in that hole.

As shown in Table 5.1, although WPs are distinct and separated, almost all of the 2-Rc volumes in the same hole overlap to some degree. Table 5.2 shows the number of possible combinations of HSUs in the minus2-Rc/WP/plus2-Rc volumes where more than one detonation was conducted in the same hole. Seventeen combinations can be formed for all simultaneous, same hole detonations, which is a fairly large variety of HSU settings for 47 individual detonations.

There is significant variety in the HSUs over the 2-Rc volumes. This will affect the initial distribution of radionuclides at the start of transport modeling, as well as how the radionuclides are released and migrate away from the detonation. Based on the uncertainty associated with determining yields, measuring cavity radii, and partitioning radionuclides around an expended nuclear detonation cavity, it may be reasonable to combine 2-Rc volumes in the same hole if these volumes are almost coincident and the HSUs are identical. A careful review of the 2-Rc volumes for each detonation within the EarthVision® model should determine if this is possible.

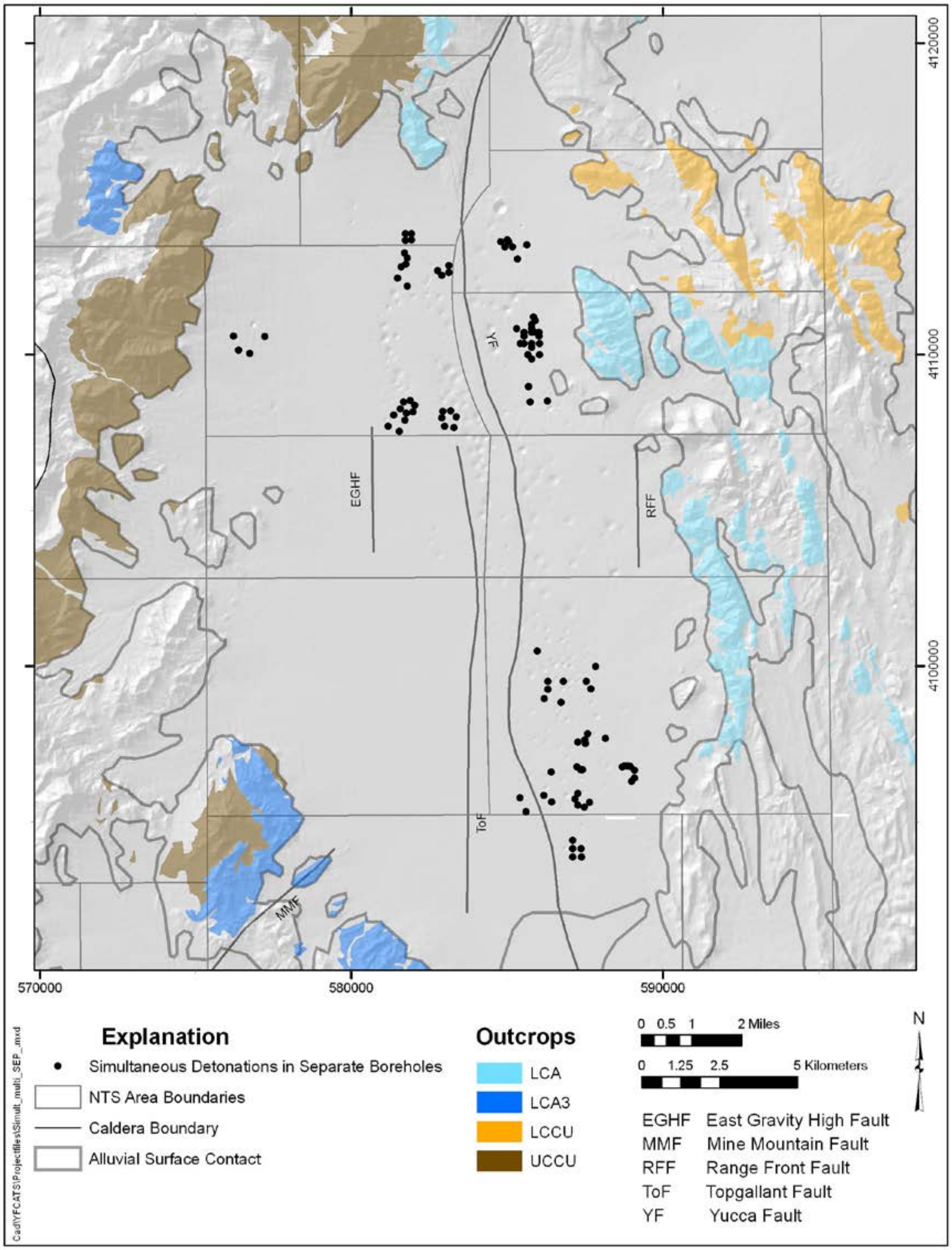

Figure 5.1 Locations for simultaneous detonations in separate holes in Yucca Flat.

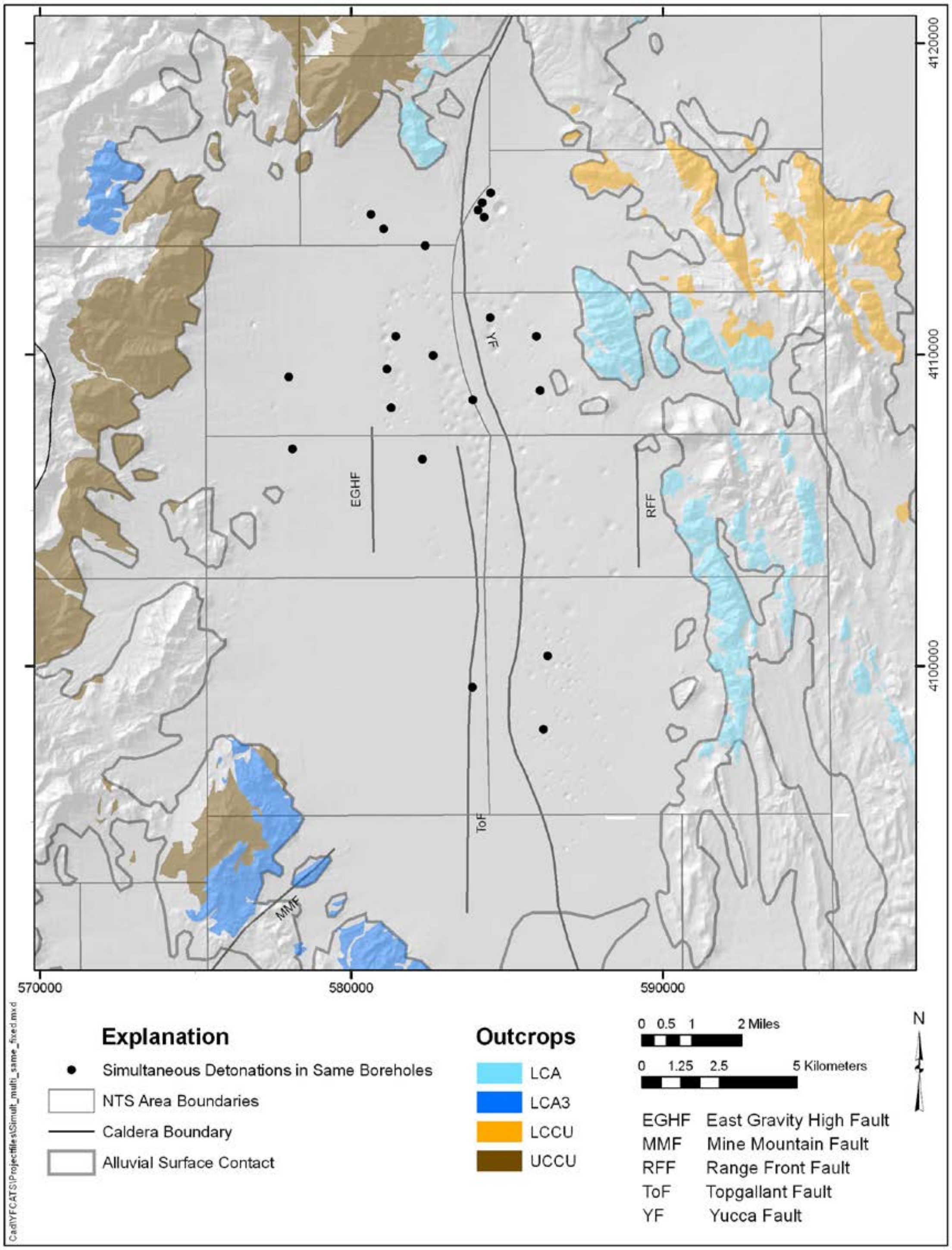

Figure 5.2 Locations where more than one detonation was conducted in the same hole in Yucca Flat.

Table 5.1 Selected information where more than one detonation was conducted in the same hole in the Yucca Flat/Climax Mine CAU (sorted by hole name).

YFDB ID	Detonation Name[a]	Hole Name[a]	Water Level (WL) Depth[b] (m)	WP minus WL (m)	Sat Detonation?	Calculated Cavity Radius (Rc)[c] (m)	WP Depth[d] (m)	WP -2-Rc (m)	WP +2-Rc (m)	WP HSU[e]	WP -2-Rc HSU[e]	WP + 2-Rc HSU[e]	Comments
735	Sundown-B	U-1d	495	-239	no	39	256	178	334	AA	AA	AA	The 2-Rc volumes are the same size and almost coincident, shifted only by the 14 m difference in WP depths. Both 2-Rc volumes are in AA; both are above the water level.
734	Sundown-A	U-1d	495	-224	no	39	270	192	348	AA	AA	AA	
153	Drill (Target-Upper)	U-2ai	557	-369	no	23	188	142	234	AA	AA	AA	The 2-Rc volume for Drill (Source-Lower) includes the 2-Rc volume for Drill (Target-Upper). WPs are in AA. The lower 2-Rc volume for Drill (Source-Lower) extends into the TMWTA. Both 2-Rc volumes are above the water level.
152	Drill (Source-Lower)	U-2ai	557	-338	no	41	219	136	301	AA	AA	TMWTA	
722	Kawich-Red	U-2cu	551	-181	no	36	370	298	442	TMLVTA	TMLVTA	TMLVTA	2-Rc volumes are of similar size and overlap at the bottom half of the upper and top half of the lower 2-Rc volumes. Both 2-Rc volumes are above the water level. Both WPs are in TM-LVTA, but the HSUs at the bottom of the 2-Rc volumes are different, with Kawich-Black ending in the LCA3.
721	Kawich-Black	U-2cu	551	-120	no	34	431	363	499	TMLVTA	TMLVTA	LCA3	
305	Crew-2nd	U-2db	561	-203	no	36	359	287	431	AA	AA	AA	Crew was not a simultaneous, same hole test, but was conducted in the same hole on the same day, 1 minute before Crew-2nd and Crew-3rd. Crew and Crew-2nd have the same WP depth. However, the Crew Rc is a bit over twice as large as that of Crew-2nd, and the 2-Rc volume of Crew-2nd is contained within the Crew 2-Rc volume. Both 2-Rc volumes are in AA. The Crew-3rd 2-Rc volume occupies unique space below the Crew 2-Rc
304	*Crew*	*U-2db*	*561*	*-203*	*no*	*77*	*359*	*205*	*513*	*AA*	*AA*	*AA*	
306	Crew-3rd	U-2db	561	41	yes	32	603	539	667	TMLVTA	AA	TMLVTA	

YFDB ID	Detonation Name[a]	Hole Name[a]	Water Level (WL) Depth[b] (m)	WP minus WL (m)	Sat Detonation?	Calculated Cavity Radius (Rc)[c] (m)	WP Depth[d] (m)	WP -2-Rc (m)	WP +2-Rc (m)	WP HSU[e]	WP -2-Rc HSU[e]	WP + 2-Rc HSU[e]	Comments
													volume, and extends from AA to TMLVTA. The 2-Rc volumes for Crew and Crew-2nd are above the water level, while the 2-Rc volume for Crew-3rd is mostly below the water level.
478	Flax-Test	U-2dj	577	-141	no	74	436	288	584	AA	AA	AA	Flax-Source was not a simultaneous, same hole test, but was conducted in the same hole on the same day about 30 seconds before Flax-Test and Flax-Backup. Flax-Test and Flax-Backup have very similar WP depths (9 m difference). However, the Rc for Flax-Test is a bit under twice as large as that of Flax-Backup, and the 2-Rc volume for Flax-Backup is contained within the Flax-Test 2-Rc volume. Both 2-Rc volumes are in the AA. The 2-Rc volume for Flax-Source occupies unique space below the Flax-Test 2-Rc volume, and extends from AA to TMLVTA. The 2-Rc volume for Flax-Backup is entirely above the water level; the 2-Rc volume for Flax-Test intercepts the water level for it's lower 7 m only; the 2-Rc volume for Flax-Source is entirely below the water level.
476	Flax-Backup	U-2dj	577	-132	no	34	445	377	513	AA	AA	AA	
477	*Flax-Source*	*U-2dj*	*577*	*111*	*yes*	*30*	*688*	*628*	*748*	*TMLVTA*	*AA*	*TMLVTA*	
514	Crestlake-Tansan	U-2dw	560	-288	no	39	272	194	350	AA	AA	AA	2-Rc volumes are of similar size and overlap at the bottom third of the upper and top third of the lower 2-Rc volumes. Both 2-Rc volumes are above the water level. While most of the 2-Rc volumes are in AA, the bottom of the lower 2-Rc volume is in TMLVTA.
513	Crestlake-Briar	U-2dw	560	-186	no	36	374	302	446	AA	AA	TMLVTA	

YFDB ID	Detonation Name[a]	Hole Name[a]	Water Level (WL) Depth[b] (m)	WP minus WL (m)	Sat Detona tion?	Calculated Cavity Radius (Rc)[c] (m)	WP Depth[d] (m)	WP -2-Rc (m)	WP +2-Rc (m)	WP HSU[e]	WP -2-Rc HSU[e]	WP + 2-Rc HSU[e]	Comments
656	Branco	U-2ew	520	-227	no	38	293	217	369	AA	AA	TMWTA	2-Rc volumes are of similar size and overlap for only about 10 m. Both 2-Rc volumes are above the water level (but Branco-Herkimer is considered a saturated test). While both 2-Rc volumes intersect similar HSUs, the WP HSUs and the HSUs for the 2-Rc volumes are different due to depth offset.
657	Branco-Herkimer	U-2ew	520	-93	yes	34	427	359	495	TMWTA	AA	TMLVTA	
711	Rhyolite	U-2ey	600	-393	no	81	207	45	369	AA	AA	LCA	USDOE, 2000b considers these to be 2 tests conducted simultaneously with each other, in the same hole. The 2-Rc volumes are of similar size and are slightly offset (by 31 m). Both 2-Rc volumes are above the water level. HSUs in both 2-Rc volumes are the same, and terminate in the LCA.
710	Nightingale	U-2ey	600	-362	no	78	238	82	394	AA	AA	LCA	
302	Bit-B	U-3gt	493	-375	no	47	118	24	212	AA	AA	AA	The 2-Rc volumes are of similar size and are slightly offset (by 30 m). Both 2-Rc volumes are above the water level. HSUs in both 2-Rc volumes are the same.
301	Bit-A	U-3gt	493	-344	no	45	148	58	238	AA	AA	AA	
730	Whiteface-B	U-3lp	481	-299	no	43	183	97	269	AA	AA	AA	The 2-Rc volumes are of similar size and are slightly offset (by 16 m). Both 2-Rc volumes are above the water level. HSUs in both 2-Rc volumes are the same.
729	Whiteface-A	U-3lp	481	-284	no	42	197	113	281	AA	AA	AA	
737	Coso-Bronze	U-4an	500	-166	no	37	333	259	407	TMWTA	AA	LTCU	The three 2-Rc volumes are of similar size. The 2-Rc volume for Gray (in the middle) is about 30 m higher than Silver (lowest), and overlaps about the lower third of the Bronze (highest)
738	Coso-Gray	U-4an	500	-58	yes	34	442	374	510	LTCU	TMLVTA	LTCU	

YFDB ID	Detonation Name[a]	Hole Name[a]	Water Level (WL) Depth[b] (m)	WP minus WL (m)	Sat Detonation?	Calculated Cavity Radius (Rc)[c] (m)	WP Depth[d] (m)	WP -2-Rc (m)	WP +2-Rc (m)	WP HSU[e]	WP -2-Rc HSU[e]	WP + 2-Rc HSU[e]	Comments
739	Coso-Silver	U-4an	500	-24	yes	34	475	407	543	LTCU	LTCU	LTCU	2-Rc volume above it. The top of the Silver 2-Rc volume and the bottom of the Bronze 2-Rc volume touch. The Bronze 2-Rc volume is above the water table. The Gray 2-Rc volume extends below the water level by 10 m. About 1/3 of the Silver 2-Rc volume extends below the water level. (Both Gray and Silver are considered saturated tests.) The HSUs for the three 2-Rc volumes are different, but all terminate in the LTCU.
724	Palisade-1	U-4at	490	-155	no	37	335	261	409	TMLVTA	TMLVTA	TMLVTA	The 2-Rc volumes are of similar size and overlap to some extent. Palisade-2 and 3 are offset by only 14 m, and both intersect the lower half of overlying Palisade-1. All three 2-Rc volumes are above the water level (but 2 and 3 are considered saturated tests). The HSUs for all three 2-Rc volumes are the same and entirely in the TMLVTA.
725	Palisade-2	U-4at	490	-100	yes	35	390	320	460	TMLVTA	TMLVTA	TMLVTA	
726	Palisade-3	U-4at	490	-87	yes	35	404	334	474	TMLVTA	TMLVTA	TMLVTA	
585	Cremino	U-8e	588	-378	no	41	210	128	292	AA	AA	TMLVTA	Each 2-Rc volume is unique. Both 2-Rc volumes are above the water level. HSUs in both 2-Rc volumes are different, but both terminate in the TMLVTA.
586	Cremino-Caerphilly	U-8e	588	-168	no	35	420	350	490	TMLVTA	TMLVTA	TMLVTA	
719	Kawich A-White	U-8n	540	-171	no	36	369	297	441	LTCU	TMLVTA	OSBCU	The 2-Rc volumes are of similar size and overlap significantly. Both 2-Rc volumes are above the water level. Although the WP HSUs are different, the HSUs in the upper and lower volumes are the same, and both volumes terminate in the OSBCU.
718	Kawich A-Blue	U-8n	540	-156	no	35	384	314	454	OSBCU	TMLVTA	OSBCU	

YFDB ID	Detonation Name[a]	Hole Name[a]	Water Level (WL) Depth[b] (m)	WP minus WL (m)	Sat Detonation?	Calculated Cavity Radius (Rc)[c] (m)	WP Depth[d] (m)	WP -2-Rc (m)	WP +2-Rc (m)	WP HSU[e]	WP -2-Rc HSU[e]	WP + 2-Rc HSU[e]	Comments
564	Gruyere	U-9cg	545	-337	no	41	207	125	289	AA	AA	AA	2-Rc volumes are of similar size and overlap at the bottom third of the upper and top third of the lower 2-Rc volumes. Both 2-Rc volumes are above the water level. While most of the 2-Rc volumes are in AA, the bottom of the lower 2-Rc volume is in TMWTA.
565	Gruyere-Gradino	U-9cg	545	-225	no	37	320	246	394	AA	AA	TMWTA	
746	Galena-Yellow	U-9cv	563	-273	no	38	290	214	366	LTCU	TMLVTA	OSBCU	The 2-Rc volumes are of similar size and overlap to some extent. Orange and Green are offset by 20 m, and both intersect the lower portion of overlying Yellow. All three 2-Rc volumes are above the water level. The HSUs for Orange and Green are the same. All three 2-Rc volumes terminate in the OSBCU.
745	Galena-Orange	U-9cv	563	-183	no	35	380	310	450	OSBCU	LTCU	OSBCU	
744	Galena-Green	U-9cv	563	-163	no	35	400	330	470	OSBCU	LTCU	OSBCU	
473	Canna-Umbrinus	U-9 ITS YZ-26	568	-385	no	43	183	97	269	TMLVTA	TMLVTA	LCA	The 2-Rc volumes are of similar size and overlap significantly. Both 2-Rc volumes are above the water level. HSUs are the same over the 2-Rc volumes, and both volumes terminate in the LCA.
472	Canna-Limoges	U-9 ITS YZ-26	568	-354	no	41	213	131	295	TMLVTA	TMLVTA	LCA	
501	Pinedrops-Sloat	U-10as	576	-362	no	41	213	131	295	AA	AA	TMLVTA	All three 2-Rc volumes overlap and are above the water table. The 2-Rc volumes penetrate HSUs from AA to LCA.
502	Pinedrops-Tawny	U-10as	576	-294	no	38	282	206	358	TMLVTA	AA	LCA	
500	Pinedrops-Bayou	U-10as	576	-233	no	36	343	271	415	TMLVTA	AA	LCA	
555	Dofino	U10ba	575	-392	no	43	183	97	269	AA	AA	AA	2-Rc volumes are of similar size and overlap at the bottom third of the upper

YFDB ID	Detonation Name[a]	Hole Name[a]	Water Level (WL) Depth[b] (m)	WP minus WL (m)	Sat Detonation?	Calculated Cavity Radius (Rc)[c] (m)	WP Depth[d] (m)	WP -2-Rc (m)	WP +2-Rc (m)	WP HSU[e]	WP -2-Rc HSU[e]	WP + 2-Rc HSU[e]	Comments
556	Dofino-Lawton	U-10ba	575	-292	no	38	282	206	358	AA	AA	TMLVTA	and top third of the lower 2-Rc volumes. Both 2-Rc volumes are above the water level. While most of the 2-Rc volumes are in AA, the bottom of the lower 2-Rc volume is in TMLVTA.
524	Portola	U-10bb	575	-377	no	42	198	114	282	AA	AA	AA	2-Rc volumes are of similar size and overlap at the bottom half of the upper and top half of the lower 2-Rc volumes. Both 2-Rc volumes are above the water level. While most of the 2-Rc volumes are in AA, the bottom of the lower 2-Rc volume is in TMLVTA.
525	Portola-Larkin	U-10bb	575	-301	no	38	275	199	351	AA	AA	TMLVTA	
698	Hazebrook-Emerald (Green)	U-10bh	571	-385	no	42	186	102	270	AA	AA	AA	2-Rc volumes are of similar size. WPs are offset by 40 m and all three 2-Rc volumes overlap (cascade). All three 2-Rc volumes are above the water table. 2-Rc volumes penetrate from AA to LTCU.
697	Hazebrook-Checkerberry (Red)	U-10bh	571	-345	no	40	226	146	306	AA	AA	LTCU	
696	Hazebrook-Apricot (Orange)	U-10bh	571	-308	no	39	262	184	340	AA	AA	LTCU	

[a]USDOE, 2000b

[b]Derived from the Yucca Flat EarthVision® hydrostratigraphic model

[c]Cavity radius is calculated from the equation [70.2 * yield (kt)$^{1/3}$] / [overburden density (Mg/m^3) * WP depth (m)]$^{1/4}$, from Pawloski, 1999, using yield from USDOE, 2000b

[d]LLNL Containment Data Base

[e]HSU information is derived from various data bases and/or the EarthVision® hydrostratigraphic model

Table 5.2 HSU information for the 2-Rc volumes for cases where more than one detonation was conducted in the same hole in Yucca Flat/Climax Mine CAU.

<table>
<tr><td rowspan="3">ALL DETONATIONS</td><td>minus2Rc</td><td colspan="5">24</td><td colspan="2">2</td><td colspan="2">4</td><td colspan="3">8</td><td colspan="2">3</td><td>1</td><td>1</td><td>2</td></tr>
<tr><td>WP</td><td colspan="5">24</td><td colspan="2">2</td><td colspan="5">12</td><td colspan="3">4</td><td colspan="2">3</td></tr>
<tr><td>plus2Rc</td><td>14</td><td>2</td><td>4</td><td>2</td><td>2</td><td>1</td><td>1</td><td>2</td><td>2</td><td>5</td><td>1</td><td>2</td><td>1</td><td>2</td><td>1</td><td colspan="2">3</td></tr>
<tr><td rowspan="3">SATURATED DETONATIONS</td><td>minus2Rc</td><td colspan="5"></td><td>1</td><td></td><td>2</td><td></td><td>2</td><td colspan="4"></td><td>1</td><td colspan="2"></td></tr>
<tr><td>WP</td><td colspan="5"></td><td>1</td><td></td><td>2</td><td></td><td>2</td><td colspan="4"></td><td>1</td><td colspan="2"></td></tr>
<tr><td>plus2Rc</td><td colspan="5"></td><td>1</td><td></td><td>2</td><td></td><td>2</td><td colspan="4"></td><td>1</td><td colspan="2"></td></tr>
<tr><td rowspan="3">UNSATURATED DETONATIONS</td><td>minus2Rc</td><td colspan="5">24</td><td></td><td>1</td><td></td><td>2</td><td colspan="3">6</td><td colspan="2">3</td><td></td><td>1</td><td>2</td></tr>
<tr><td>WP</td><td colspan="5">24</td><td></td><td>1</td><td></td><td>2</td><td colspan="3">6</td><td colspan="2">3</td><td></td><td colspan="2">3</td></tr>
<tr><td>plus2Rc</td><td>14</td><td>2</td><td>4</td><td>2</td><td>2</td><td></td><td>1</td><td></td><td>2</td><td>3</td><td>1</td><td>2</td><td>1</td><td>2</td><td></td><td colspan="2">3</td></tr>
</table>

Legend (HSUs are identified in Table 1.2)

AA
TM-UVTA
UTCU
TM-WTA
TM-LVTA
LTCU
OSBCU
ATCU
MGCU
LCA3
LCA
UCCU
LCCU

Categories of detonations for simultaneous, same hole detonations in Yucca Flat/Climax Mine CAU:

All detonations—17

Saturated detonations—4

Unsaturated detonations—14

5.2 Detonations in Special Areas

Some regions of Yucca Flat were designed for either operational needs or containment reasons. Other regions became known simply because of groupings in geographic locations. Detonations in several areas were evaluated to determine if characteristics were sufficiently similar to permit detonation grouping for radionuclide nuclide transport modeling.

5.2.1 Area 9 ITS Region

The ITS (integrated test system) region is located in north central Area 9. This region was identified by LLNL to host numerous proximally located detonations. Characterization activities, planning, and operations were purposefully similar and more streamlined for these nearby detonations, permitting a shortened turnaround schedule. Almost all of these detonations, occurring between January 1970 and December 1972, were either simultaneous detonations in separate holes or simultaneous detonations in the same hole. The square ITS region is located between the Yucca Fault to the west and the Area 9 Fault to the east, approximately between Nevada State Plane coordinates N866,500 and N972,500 (NAD27). The region was gridded from 17 to 31 in the north-south direction and M to EE in the east-west direction (it is possible that the original grid was larger than this, but current maps show the ITS region to be this size). Holes were named by their grid locations. For example, hole U-9 ITS X-27 was located in the Area 9 ITS region on grid location X-27. Geologically, this region is located on the east side of the Yucca Flat basin, where the basin fill thins and pre-Tertiary rocks are nearer to the ground surface. Although small faults have been identified in the ITS region, no faults with large displacement are present.

Of the 118 Area 9 detonations, 34 were located in the ITS region (Table 5.3, sorted in the order of detonation occurrence). However, only 26 of these are considered ITS region detonations. Additional drill holes in the ITS region include 8 detonations that were executed before the ITS region was identified (i.e., earlier than 1970) and 10 exploratory and instrument drill holes.

All ITS region detonations are unsaturated, and the 2-Rc volumes are located a considerable distance from the water table. All 26 ITS region detonations were announced at <20 kt yield. Because of the relatively small yield, calculated cavity radii are also relatively small, ranging from 35 to 49 m. WPs are between 101 and 412 m deep, well above the water table in this part of Yucca Flat (approximately 550–570 m). The closest the bottom of the 2-Rc cavity volume (plus2-Rc depth) comes to the water table is 65 m, for a total of about 4-Rc distance from the WP to the water table. The average distance from the WP down to the water table is about 6 Rc.

Table 5.4 shows that 85% of the WPs detonations for detonations in the ITS region were located in vitric tuff (TM-LVTA) and 15% were in altered tuff (LTCU). All upper 2-Rc volumes were either alluvium or vitric tuff (AA or TM-LVTA), while lower 2-Rc volumes encompassed vitric tuff, altered tuff, or carbonate aquifer (TM-LVTA, LTCU, OSBCU or LCA).

If the unsaturated WP for each detonation is projected to the water table, 25 of the points (96%) would occur in the LCA, and one would occur in OSBCU. Eleven of the detonations collapsed to the surface and formed a surface crater, while 15 experienced subsurface collapse.

There are numerous similarities among detonations located in the ITS region, as identified in the above paragraphs. Analysis of the 2-Rc volumes shows eight categories of detonations that can be identified. It seems reasonable that the total number of detonations can be reduced to the categories identified in Table 5.4.

CANNA-LIMOGES and CANNA-UMBRINUS are located in the same hole. While their 2-Rc volumes were composed of the same HSUs, the volumes were slightly different in size and offset. As mentioned above for other simultaneous, same hole detonations, it may be possible to combine the two 2-Rc volumes into one and distribute both source terms in the one volume. A careful review of the 2-Rc volumes for U-9 ITS YZ-26 within the EarthVision® model should determine if this is possible.

Table 5.3 Selected data for detonations in the Area 9 ITS region.

YFDB ID	DETONATION NAME[a]	HOLE NAME[a,d]	WATER LEVEL (WL) DEPTH[b] (M)	WP MINUS WL (M)	SAT DETONATION?	CALC CAVITY RADIUS (RC)[c] (M)	WP DEPTH[d] (M)	WP -2-RC (M)	WP +2-RC (M)	WP HSU[e]	WP -2-RC HSU[e]	WP +2-RC HSU[e]	HSU AT WATER TABLE[e]	COLLAPSE TO SURFACE?[d]
370	Fob-Blue	U-9 ITS Y-27	567	-467	no	49	101	3	199	TMLVTA	AA	TMLVTA	LCA	no
371	Fob-Green	U-9 ITS V-27	560	-315	no	40	244	164	324	TMLVTA	TMLVTA	TMLVTA	LCA	yes
372	Fob-Red	U-9 ITS V-24	556	-290	no	39	266	188	344	TMLVTA	TMLVTA	LTCU	LCA	yes
381	Arabis-Blue	U-9 ITS Z-26	571	-470	no	49	101	3	199	TMLVTA	AA	TMLVTA	LCA	no
382	Arabis-Green	U-9 ITS X-28	565	-306	no	39	259	181	337	TMLVTA	TMLVTA	LCA	LCA	no
383	Arabis-Red	U-9 ITS V-26	558	-308	no	39	250	172	328	TMLVTA	TMLVTA	LTCU	LCA	yes
391	Hod-A (Green)	U-9 ITS X-23	562	-321	no	40	241	161	321	TMLVTA	TMLVTA	LTCU	LCA	yes
392	Hod-B (Red)	U-9 ITS X-20	560	-295	no	39	265	187	343	TMLVTA	TMLVTA	LTCU	LCA	yes
393	Hod-C (Blue)	U-9 ITS Z-25	570	-469	no	49	101	3	199	TMLVTA	AA	LCA	LCA	no
401	Piton-A	U-9 ITS Y-30	568	-332	no	40	237	157	317	TMLVTA	TMLVTA	LCA	LCA	no
402	Piton-B	U-9 ITS X-27	564	-335	no	40	230	150	310	TMLVTA	TMLVTA	LTCU	LCA	yes
403	Piton-C	U-9 ITS AA-25	573	-472	no	49	101	3	199	TMLVTA	AA	LCA	LCA	no
406	Scree-Acajou	U-9 ITS X-24	563	-314	no	39	249	171	327	TMLVTA	TMLVTA	LCA	LCA	yes
407	Scree-Alhambra	U-9 ITS Z-21	568	-375	no	42	192	108	276	TMLVTA	TMLVTA	LCA	LCA	yes
408	Scree-Chamois	U-9 ITS Z-24	569	-469	no	49	101	3	199	TMLVTA	AA	LCA	LCA	no
418	Avens-Alkermes	U-9 ITS U-24	554	-248	no	37	306	232	380	TMLVTA	TMLVTA	LTCU	LCA	no
419	Avens-Andorre	U-9 ITS T-28	555	-176	no	35	379	309	449	LTCU	TMLVTA	LTCU	LCA	yes
420	Avens-Asamlte	U-9 ITS W-21	557	-249	no	37	308	234	382	LTCU	TMLVTA	OSBCU	LCA	yes
421	Avens-Cream	U-9 ITS X-29	566	-273	no	38	293	217	369	LTCU	TMLVTA	LCA	LCA	yes

YFDB ID	DETONATION NAME[a]	HOLE NAME[a,d]	WATER LEVEL (WL) DEPTH[b] (M)	WP MINUS WL (M)	SAT DETONATION?	CALC CAVITY RADIUS (RC)[c] (M)	WP DEPTH[d] (M)	WP -2-RC (M)	WP +2-RC (M)	WP HSU[e]	WP -2-RC HSU[e]	WP +2-RC HSU[e]	HSU AT WATER TABLE[e]	COLLAPSE TO SURFACE?[d]
433	Nama-Amarylis	U-9 ITS XY-31	568	-295	no	38	273	197	349	LTCU	TMLVTA	LCA	LCA	no
434	Nama-Mephisto	U-9 ITS Z-27	571	-327	no	40	244	164	324	TMLVTA	TMLVTA	LCA	LCA	no
435	Baltic	U-9 ITS S-25	547	-135	no	35	412	342	482	TMLVTA	TMLVTA	LTCU	OSBCU	no
462	Haplopappus	U-9 ITS W-22	558	-374	no	42	184	100	268	TMLVTA	TMLVTA	LTCU	LCA	no
472	Canna-Limoges	U-9 ITS YZ-26	568	-354	no	41	213	131	295	TMLVTA	TMLVTA	LCA	LCA	no
473	Canna-Umbrinus	U-9 ITS YZ-26	568	-385	no	43	183	97	269	TMLVTA	TMLVTA	LCA	LCA	no
475	Solanum	U-9 ITS W-24.5	561	-360	no	42	201	117	285	TMLVTA	TMLVTA	TMLVTA	LCA	no
51	Raritan	U-9u	540	-384	no	44	156	68	244	AA	AA	AA	TMLVTA	yes
108	Eagle	U-9av	541	-376	no	28	165	109	221	AA	AA	AA	TMLVTA	yes
114	Bunker	U-9bb	564	-338	no	40	226	146	306	TMLVTA	TMLVTA	TMLVTA	LCA	yes
118	Handicap	U-9ba	554	-410	no	45	144	54	234	AA	AA	TMLVTA	OSBCU	yes
299	Vat	U-9cf	543	-348	no	42	195	111	279	AA	AA	TMWTA	LTCU	yes
309	Tinderbox	U-9az	547	-108	no	34	440	372	508	LTCU	TMLVTA	LTCU	OSBCU	no
320	Biggin	U-9bz	545	-303	no	40	242	162	322	TMLVTA	AA	TMLVTA	OSBCU	no
325	Valise	U-9by	548	-456	no	51	91	-11	193	AA	AA	AA	OSBCU	no
Instrument hole		UE-9 U-29-1												
Exploratory hole		UE-9 XY-30.5												

[a]USDOE, 2000b
[b]Derived from the Yucca Flat EarthVision® hydrostratigraphic model
[c]Calculated cavity radius from [70.2 * Max Yield$^{1/3}$ (kt)] / [overburden density (Mg/m^3) * WP depth (m)]$^{1/4}$, using yield from USDOE, 2000b
[d]LLNL Containment Data Base
[e]HSU information is derived from various data bases and/or the EarthVision® hydrostratigraphic model

Table 5.4 HSU information for the 2-Rc volumes for detonations located in the Area 9 ITS region.

ALL DETONATIONS	**minus2Rc**	5		17			4		
	WP	22					4		
	plus2Rc	2	3	2	8	7	1	1	2
SATURATED DETONATIONS	**minus2Rc**								
	WP								
	plus2Rc								
UNSATURATED DETONATIONS	**minus2Rc**	5		17			4		
	WP	22					4		
	plus2Rc	2	3	2	8	7	1	1	2

Legend (HSUs are identified in Table 1.2)

AA
TM-UVTA
UTCU
TM-WTA
TM-LVTA
LTCU
OSBCU
ATCU
MGCU
LCA3
LCA
UCCU
LCCU

Categories of detonations for WPs located in the Area 9 ITS region:

All detonations—8

Saturated detonations—0

Unsaturated detonations—8

5.2.2 Sand Pile

In the early 1970s, Los Alamos National Laboratory (LANL) identified a portion of southern Area 3 as having thick, tuff-rich sandy alluvium, simple geologic structure, and relatively deep pre-Tertiary rocks (Fernald, 1983). The evaluation of geologic and geophysical data from 26 drill holes allowed LANL to conclude that material properties were very uniform and that the outgoing shock wave from underground nuclear detonations in this area would react in a predictable way. They identified this area between the Yucca Fault to the west and the Embudo and Area 3 faults to the east, within approximately N820,000 north and N830,000 south and less than 335 m deep, as the “Area 3 Sand Pile.” For containment reasons, they determined that all proposed detonations within this area would only need to have a minimum amount of new data collected, and as long as the new data was within the bounds of the existing characterization data, no additional data needed to be gathered. The Sand Pile was extended in 1981 to include depths to 457 m (same area extent).

The Sand Pile includes 41 detonations and 3 characterization holes (Table 5.5). Most of these detonations occurred in the 1970s, with a few in the 1980s. The latest detonation (WHITEFACE-A) occurred in 1989. All WPs were above the water table, with most significantly above it. Eight of the 41 detonations are considered by UGTA to be saturated detonations (in this case, above the water table but within 100 m of it). Five of the saturated detonations had the bottom of the 2-Rc volume below the water table (in the saturated zone). Thirty-six detonations had the 2-Rc volume above the water table; 29 of these detonations had the 2-Rc volume greater than an additional 2-Rc distance above the water table.

Almost all of the Sand Pile detonations had WPs in alluvium. Three detonations had WPs located in tuffs just below the tuff-alluvium contact. As shown in Table 5.6, the upper 2-Rc radius extended into the AA for all detonations, and the lower 2-Rc radius included the AA, TMUVTA, TMWTA, TMLVTA, and LTCU. Sixty-three percent of these detonations (26 of 41) had the entire 2-Rc volume in the AA. Twenty percent of the detonations (12 of 41) had at least the upper portion of the 2-Rc volume and WP in AA, but the lower portion was in tuff (TMUVTA, TMWTA, and TMLVTA). Seven percent of the detonations (3 of 41) had the upper 2-Rc volume in the AA and the WP and lower 2-Rc volume in tuff (TMUVTA, TMWTA, TMLVTA, and LTCU).

All 41 detonations had WPs above the water table, but if the WPs were translated directly below to the water table, 13 of the detonations would project to the AA, 4 to the TMUVTA, 3 to the TMWAT, 16 to the TMLVTA, and 5 to the LTCU.

Only one-third of these detonations collapsed to the surface.

Table 5.6 shows that seven categories can be formed for detonations in the Sand Pile. Two-thirds of the detonations occur in one category (all the 2-Rc volume is in AA). Due to the similarity of material properties that allowed LANL to develop the Sand Pile concept, it seems quite reasonable that the total number of detonations in this area can be reduced to the categories identified by Table 5.6.

Table 5.5 Selected data for detonations located in the Area 3 Sand Pile.

YFDB ID	Detonation Name[a]	Hole Name[a]	Sand Pile 1 or 2	Water Level (WL) Depth[b] (m)	WP minus WL (m)	Sat Deton-ation?	Calc Cavity Radius (Rc)[c] (m)	WP Depth (m)	WP -2Rc (m)	WP +2-Rc (m)	WP HSU[e]	WP -2-Rc HSU[e]	WP +2-Rc HSU[e]	HSU at Water Table[e]	Collapse to surface?[d]
515	Puye	U-3jL	1	482	-52	yes	34	430	362	498	AA	AA	AA	AA	no
498	Elida	U-3hy	1	471	-90	yes	35	381	311	451	AA	AA	AA	AA	no
511	Jara	U-3hp	1	471	-93	yes	35	378	308	448	AA	AA	AA	TMUVTA	no
644	Seyval	U-3Lm	2	481	-115	no	36	366	294	438	AA	AA	AA	AA	yes
618	Clairette	U-3kr	2	475	-122	no	36	354	282	426	AA	AA	AA	AA	no
554	Oarlock	U-3km	2	476	-158	no	37	318	244	392	AA	AA	AA	AA	no
611	Huron King	U-3ky	2	481	-161	no	37	320	246	394	AA	AA	AA	AA	no
517	Pratt	U-3hq	1	476	-162	no	37	314	240	388	AA	AA	AA	AA	yes
450	Cowles	U-3hx	1	468	-166	no	38	302	226	378	AA	AA	AA	TMWTA	yes
582	Jackpots	U-3kj	2	479	-175	no	37	304	230	378	AA	AA	AA	AA	no
447	Hospah	U-3je	1	482	-180	no	38	302	226	378	AA	AA	AA	AA	no
495	Bernal	U-3jy	1	475	-190	no	38	285	209	361	AA	AA	AA	TMUVTA	yes
454	Onaja	U-3js	1	471	-192	no	38	279	203	355	AA	AA	AA	TMLVTA	no
432	Barranca	U-3he	1	481	-210	no	39	271	193	349	AA	AA	AA	LTCU	no
474	Tuloso	U-3gi	1	483	-212	no	39	271	193	349	AA	AA	AA	TMLVTA	yes
485	Colmor	U-3hv	1	475	-229	no	40	246	166	326	AA	AA	AA	TMLVTA	yes
590	Concentra-tion	U-3kn	2	483	-240	no	40	243	163	323	AA	AA	AA	TMLVTA	yes
440	Frijoles-Petaca	U-3hz	1	479	-254	no	40	226	146	306	AA	AA	AA	LTCU	yes
453	Ocate	U-3jp	1	469	-259	no	41	210	128	292	AA	AA	AA	TMLVTA	no
627	Cernada	U-3kk	2	473	-260	no	41	213	131	295	AA	AA	AA	TMUVTA	no
574	Rib	U-3jv	2	477	-264	no	41	213	131	295	AA	AA	AA	TMLVTA	yes
466	Cuchillo	U-3jt	1	469	-271	no	42	199	115	283	AA	AA	AA	TMWTA	no
729	White-face-A	U-3Lp	2	481	-284	no	42	197	113	281	AA	AA	AA	AA	yes
455	Jicarilla	U-3jm	1	470	-322	no	45	148	58	238	AA	AA	AA	TMLVTA	no
467	Solano	U-3jx	2	468	-334	no	46	134	42	226	AA	AA	AA	TMLVTA	no
426	Dexter	U-3hs	1	475	-354	no	47	120	26	214	AA	AA	AA	TMLVTA	no

YFDB ID	Detonation Name[a]	Hole Name[a]	Sand Pile 1 or 2	Water Level (WL) Depth[b] (m)	WP minus WL (m)	Sat Deton-ation?	Calc Cavity Radius (Rc)[c] (m)	WP Depth (m)	WP -2Rc (m)	WP +2-Rc (m)	WP HSU[e]	WP -2-Rc HSU[e]	WP +2-Rc HSU[e]	HSU at Water Table[e]	Collapse to surface?[d]
425	Embudo	U-3hd	1	484	-181	no	38	303	227	379	AA	AA	TMLVTA	LTCU	yes
483	Angus	U-3jg	1	472	-20	yes	34	453	385	521	AA	AA	TMUVTA	AA	no
567	Scupper	U-3hj	2	478	-29	yes	34	450	382	518	AA	AA	TMUVTA	AA	no
535	Marsh	U-3kb	2	480	-53	yes	34	427	359	495	AA	AA	TMUVTA	AA	no
572	Seamount	U-3kp	2	479	-109	no	36	370	298	442	AA	AA	TMUVTA	TMWTA	no
612	Verdello	U-3ku	2	476	-110	no	36	366	294	438	AA	AA	TMUVTA	TMUVTA	no
536	Deck	U-3kd	2	472	-146	no	37	326	252	400	AA	AA	TMUVTA	TMLVTA	no
465	Cebolla	U-3jc	1	472	-185	no	38	287	211	363	AA	AA	TMUVTA	TMLVTA	no
439	Frijoles-Guaje	U-3hf	1	479	-222	no	39	257	179	335	AA	AA	TMUVTA	LTCU	no
541	Shallows	U-3jf	1	481	-237	no	40	245	165	325	AA	AA	TMUVTA	LTCU	yes
523	Keel	U-3hu	1	473	-169	no	37	305	231	379	AA	AA	TMWTA	TMLVTA	yes
464	Atarque	U-3ht	1	474	-179	no	38	294	218	370	AA	AA	TMWTA	TMLVTA	yes
520	Estaca	U-3ja	1	470	-149	no	37	321	247	395	TMUV TA	AA	TMWTA	TMLVTA	no
427	Laguna	U-3fd	1	480	-25	yes	73	455	309	601	TMW TA	AA	LTCU	TMLVTA	no
570	Bobstay	U-3jb	1	471	-90	yes	35	381	311	451	TMW TA	AA	TMLVTA	TMLVTA	no
		U-3ka	2												
		U-3ki	2												
		U-3kl	2												

[a]USDOE, 2000b
[b]Derived from the Yucca Flat EarthVision® hydrostratigraphic model
[c]Calculated cavity radius from [70.2 * Max Yield$^{1/3}$ (kt)] / [overburden density (Mg/m^3) * WP depth (m)]$^{1/4}$, using yield from USDOE, 2000b
[d]LLNL Containment Data Base
[e]HSU information is derived from various data bases and/or the EarthVision® hydrostratigraphic model

Table 5.6 HSU information for the 2-Rc volumes for detonations located in the Area 3 Sand Pile

ALL DETONATIONS	**minus2Rc**	**38**				**1**	**2**	
	WP	**38**				**1**	**2**	
	plus2Rc	**26**	**9**	**2**	**1**	**1**	**1**	**1**
SATURATED DETONATIONS	**minus2Rc**	**6**					**2**	
	WP	**6**					**2**	
	plus2Rc	**3**	**3**				**1**	**1**
UNSATURATED DETONATIONS	**minus2Rc**	**32**				**1**		
	WP	32				1		
	plus2Rc	23	6	2	1	1		

Legend (HSUs are identified in Table 1.2)

AA
TM-UVTA
UTCU
TM-WTA
TM-LVTA
LTCU
OSBCU
ATCU
MGCU
LCA3
LCA
UCCU
LCCU

Categories of detonations with WPs in the Area 3 Sand Pile:

All detonations—7

Saturated detonations—4

Unsaturated detonations—5

5.2.3 Tuff Pile

In 1983 LANL proposed a Tuff Pile, following on the concept of the Sand Pile (App and Marusak, 1997). The Tuff Pile is located between the Topgallant and Yucca faults in southern Yucca Flat Areas 3, 4, and 7, north of N840,000 and south of N855,000. The north boundary was arbitrary, but coincident with the southern extent of a buried east–west-trending Paleozoic ridge. Sufficient data had been evaluated to determine that the area was well characterized and structurally simple. Subsequently collected data was as expected when compared to existing data. For a proposed detonation to meet Tuff Pile criteria, the WP would be located in tuff, sufficiently below the tuff/alluvium interface to minimize CO_2 generation.

The Tuff Pile became known for anomalously high potentiometric measurements after underground nuclear testing occurred in the region. Post-test heads have remained above historic pre-testing water levels for decades and are slowly diffusing. The UGTA Project is investigating the issue. In a scoping study, Wohletz et al. (1999) show that low permeability rock surrounding nuclear detonations can pressurize the disturbed zone and elevated hydraulic heads may be created for a substantial amount of time. Wolfsberg et al. (2006) investigated dual-porosity flow and transport models to preserve pore fluid pressure and also permit fracture flow. It seems reasonable that the increased potentiometric surface is caused by the presence of low permeability units in the saturated zone and constraints caused by faults bounding this localized basin. Radionuclides initially deposited within the 2-Rc volume should experience restricted groundwater migration in low permeability units. However, it is not clear if the pressure pulse from the nuclear explosion can “push” radionuclides outward from a given detonation to a more permeable unit or a fault, or what the impact of an explosion will be on a nearby previous detonation setting in the Tuff Pile. The cause, duration, and impact of sustained pressurization remains an important issue in large-scale transport modeling.

The Tuff Pile includes 25 detonations with WPs in tuff (Table 5.7). Most WPs (68%) were located in altered tuff, 28% were in vitric tuff, and 4% in welded tuff. To identify WP HSUs, 4 detonations had WPs in the TMUVTA, 1 detonation had a WP in TMWTA, 3 detonations had WPs in TMLVTA, and 17 detonations had WPs in the LTCU. Seventeen of the detonations (68%) had WPs located below the water table, and 20 of the detonations are considered saturated. Most detonations are significantly below the water table; for 19 detonations, the bottom of the 2-Rc volume is greater that 1 additional cavity radius below the water table.

Table 5.8 shows HSUs for the 2-Rc volumes for detonations in the Tuff Pile. Upper 2-Rc volumes include a range of HSUs—from the AA to the LTCU. HSUs with higher permeability in the upper 2-Rc volume may be particularly important for radionuclide migration in this high-pressure area. Lower 2-Rc volumes range from TMWTA to ATCU. Because of the wide range of HSUs included in the 2-Rc volumes, a large number of categories (10) can be formed for detonations in the Tuff Pile.

Sixty percent of the detonations in the Tuff Pile collapsed to the surface.

The TRANSOM device was emplaced in U-4f and scheduled for execution on May 10, 1978. It did not detonate. The TRANSOM device was destroyed, as planned, by the HEARTS detonation in nearby U-4n on September 6, 1979. TRANSOM was emplaced positioned at a WP of 640 m, 168 m below the water level. TRANSOM had no nuclear yield, which prohibits calculating a cavity volume in which to place radionuclide inventory. See Section 5.4 for more discussion.

Table 5.7 Selected data for detonations in the Tuff Pile.

YFDB ID	Detonation Name[a]	Hole Name[a]	Water Level (WL) Depth[b] (m)	WP minus WL (m)	Sat deton-ation?	Calc Cavity Radius (Rc)[c] (m)	WP Depth[d] (m)	WP-2-Rc (m)	WP +2-Rc (m)	WP HSU[e]	WP -2-Rc HSU[e]	WP + 2-Rc HSU[e]	HSU at Water Table[e]	Collapse to surface?[d]
617	Baseball	U-7ba	458	105	yes	63	564	438	690	LTCU	LTCU	ATCU	LTCU	yes
643	Borrego	U-7br	493	70	yes	63	563	437	689	LTCU	LTCU	ATCU	LTCU	no
636	Bouschet	U-3La	479	85	yes	63	564	438	690	LTCU	LTCU	LTCU	LTCU	no
581	Transom	U-4f	472	168	yes	0	640	640	640	LTCU	LTCU	LTCU	LTCU	no
633	Jornada	U-4j	477	162	yes	59	639	521	757	LTCU	LTCU	LTCU	LTCU	no
601	Hearts	U-4n	473	167	yes	60	640	520	760	LTCU	LTCU	LTCU	TMLVTA	yes
571	Sandreef	U-7aq	479	222	yes	60	701	581	821	LTCU	LTCU	LTCU	TMWTA	yes
588	Rummy	U-7au	489	151	yes	61	640	518	762	LTCU	LTCU	LTCU	TMWTA	yes
663	Tortugas	U-3gg	474	165	yes	61	639	517	761	LTCU	LTCU	OSBCU	LTCU	yes
704	Tahoka	U-3mf	487	151	yes	61	639	517	761	LTCU	LTCU	OSBCU	LTCU	yes
715	Dalhart	U-4u	477	162	yes	61	640	518	762	LTCU	LTCU	OSBCU	LTCU	yes
544	Billet	U-7an	487	150	yes	61	636	514	758	LTCU	LTCU	OSBCU	LTCU	no
559	Crewline	U-7ap	498	66	yes	63	564	438	690	LTCU	LTCU	OSBCU	LTCU	no
584	Lowball	U-7av	490	75	yes	63	565	439	691	LTCU	LTCU	OSBCU	LTCU	yes
688	Kinibito	U-3me	496	84	yes	62	579	455	703	LTCU	TMLVTA	LTCU	LTCU	yes
648	Turquoise	U-7bu	480	53	yes	64	533	405	661	LTCU	TMLVTA	LTCU	LTCU	yes
741	Lubbock	U-3mt	468	-11	yes	66	457	325	589	LTCU	TMWTA	LTCU	LTCU	yes
678	Vaughn	U-3Lr	489	-63	yes	67	426	292	560	TMLVTA	TMUVTA	LTCU	LTCU	no
694	Aleman	U-3kz	475	28	yes	33	503	437	569	TMLVTA	TMWTA	LTCU	TMWTA	no
116	Mackerel	U-4b	484	-150	no	37	334	260	408	TMLVTA	TMWTA	TMLVTA	LTCU	no
646	Coalora	U-3lo	492	-218	no	38	274	198	350	TMUVTA	AA	TMWTA	LTCU	yes
626	Trebbiano	U-3Lj	486	-181	no	37	305	231	379	TMUVTA	AA	TMWTA	TMLVTA	yes
675	Vermejo	U-4r	467	-117	no	36	350	278	422	TMUVTA	AA	TMWTA	TMWTA	yes
727	Tulia	U-4s	471	-73	yes	35	398	328	468	TMUVTA	AA	TMWTA	TMWTA	no
613	Bonarda	U-3gv	490	-109	no	69	381	243	519	TMWTA	AA	LTCU	TMLVTA	yes

[a]USDOE, 2000b

[b]Derived from the Yucca Flat EarthVision® hydrostratigraphic model

[c]Calculated cavity radius from [70.2 * Max Yield$^{1/3}$ (kt)] / [overburden density (Mg/m^3) * WP depth (m)]$^{1/4}$, using yield from USDOE, 2000b

[d]LLNL Containment Data Base

[e]HSU information is derived from various data bases and/or the EarthVision® hydrostratigraphic model

Table 5.8 HSU information for the 2-Rc volumes for detonations located in the Tuff Pile.

ALL DETONATIONS	minus2Rc	4	1	1	2		1	2	14		
	WP	4	1	3			17				
	plus2Rc	2	1	1	1	1	3		6	6	2
SATURATED DETONATIONS	minus2Rc	3	1				1	2	8		
	WP	3	1				3		8		
	plus2Rc	3	1				3		3	4	1
UNSATURATED DETONATIONS	minus2Rc	1		1	2				6		
	WP	1		3					6		
	plus2Rc	1		1	1	1			3	2	1

Legend (HSUs are identified in Table 1.2)

AA
TM-UVTA
UTCU
TM-WTA
TM-LVTA
LTCU
OSBCU
ATCU
MGCU
LCA3
LCA
UCCU
LCCU

Categories of detonations with WPs located in the Tuff Pile:

All detonations—10

Saturated detonations—7

Unsaturated detonations—7

5.2.4 Western Areas 2 and 4

The western portions of Areas 2 and 4 comprise a small graben located west of the Gravity High. Basin fill is composed of coarse mixed alluvium and older tuffs, the youngest tuff present being the Rainier Mesa tuff. The basin fill sequence is thinner in western Areas 2 and 4 when compared to the main Yucca Flat basin. The pre-Tertiary rock surface is also higher in this basin than in the Yucca Flat basin. West of the Carpetbag Fault, the pre-Tertiary rock is thrusted LCA3. Seismic data shows that a minor horst is present in some portions of the graben.

Western Area 2 hosted 11 detonations from 1966 to 1969. In 1980, LLNL completed extensive seismic surveys to define the depth to the pre-Tertiary rock surface. Based on this information, testing resumed in western Area 2 and proceeded south into western Area 4. Eleven detonations were conducted after 1980.

The POD detonations in 1969 were simultaneous detonations conducted in separate holes. KAWICH RED and KAWICH BLACK (in U-2cu) and PALISADE 1, 2, and 3 (in U-4at) were simultaneous detonations in the same holes.

Table 5.9 summarizes selected information for detonations in western Areas 2 and 4. WPs for the 22 detonations were all above the water table. Four detonations were within 55 to 100 m of the water table and are considered saturated (PALISADE 2 and 3, ROQUEFORT, and STODDARD). The lower 2-Rc volume would intersect the water table for three detonations (GORBEA, ROQUEFORT, and STODDARD). Most of the detonations were significantly above the water table—the lower 2-Rc volume is greater than an additional 1.5 Rc above the water table for 17 of the detonations.

WP HSUs for this area were varied and spanned the hydrostratigraphic sequence, as shown in Table 5.10. This is due to the thinner basin fill section. Three detonations were conducted in the AA, 1 detonation in the TMWTA, 17 detonations in the TMLVTA, and 1 detonation in the LCA3. The upper 2-Rc volume ranged from AA, TMWTA, and TMLVTA to LCA3. The lower 2-Rc volumes ranged from TMLVTA, LTCU, and ATCU to LCA3. If the unsaturated WPs were translated directly below to the water table, three would occur in the TM-LVTA, one in the ATCU, nine in the LCA3, and five in the UCCU.

Sixty-four percent of the detonations (14 of 22) collapsed to the surface.

The large numbers of categories identified for detonations in western Areas 2 and 4 precludes reducing the numbers of detonations by categorization.

The NASH detonation in U-2ce was unusual in that it was the only detonation at the NTS that had a WP in the LCA3. Only NASH and three other detonations had WP in the carbonate aquifer—HANDCAR in U-10b, KANKAKEE in U-10p, and BOURBON in U-7nS (these three detonations were located in the LCA). The upper 2-Rc volume for NASH was in TMLVTA. Although located in a deeper HSU, the NASH WP, at 3.6 Rc above the water table, was unsaturated. Tritium was detected in UE-2ce, a water sampling well located approximately 182 m from the NASH emplacement hole.

Table 5.9 Selected data for western Areas 2 and 4 detonations.

YFDB ID	Detonation Name[a]	Hole Name[a]	Water Level (WL) Depth[b] (m)	WP minus WL (m)	Sat deton-ation?	Calc Cavity Radius (Rc)[c] (m)	WP Depth[d] (m)	WP -2-Rc (m)	WP +2-Rc (m)	WP HSU[e]	WP -2-Rc HSU[e]	WP + 2-Rc HSU[e]	HSU at Water Table[e]	Collapse to surface?[d]
207	Traveler	U-2cd	497	-300	no	42	198	114	282	AA	AA	LTCU	LCA3	yes
240	Heilman	U-2cg	531	-379	no	45	153	63	243	AA	AA	TMLVTA	LCA3	no
355	Pod-C	U-2ci	466	-296	no	41	171	89	253	AA	AA	TMLVTA	UCCU	no
230	Nash	U-2ce	527	-163	no	45	364	274	454	LCA3	TMLVTA	LCA3	UCCU	yes
203	Stutz	U-2ca	466	-240	no	40	226	146	306	TMLVTA	AA	LTCU	LCA3	yes
356	Pod-D	U-2cj	512	-200	no	35	312	242	382	TMLVTA	AA	LTCU	LCA3	yes
218	Saxon	U-2cc	536	-383	no	17	154	120	188	TMLVTA	AA	TMLVTA	UCCU	yes
662	Gorbea	U-2cq	521	-133	no	69	388	250	526	TMLVTA	TMLVTA	ATCU	ATCU	yes
296	Stoddard	U-2cm-S	522	-55	yes	39	467	390	546	TMLVTA	TMLVTA	LCA3	ATCU	no
686	Roquefort	U-4as	508	-92	yes	68	415	279	551	TMLVTA	TMLVTA	LCA3	ATCU	no
721	Kawich-Black	U-2cu	551	-120	no	34	431	363	499	TMLVTA	TMLVTA	LCA3	LCA3	yes
354	Pod-B	U-2ch	444	-195	no	37	249	175	323	TMLVTA	TMLVTA	LTCU	UCCU	no
353	Pod-A	U-2ck	540	-274	no	36	267	195	339	TMLVTA	TMLVTA	TMLVTA	LCA3	no
635	Kryddost	U-2co	516	-180	no	37	335	261	409	TMLVTA	TMLVTA	TMLVTA	TMLVTA	no
673	Wexford	U-2cr	558	-244	no	37	314	240	388	TMLVTA	TMLVTA	TMLVTA	UCCU	yes
682	Maribo	U-2cs	547	-166	no	35	381	311	451	TMLVTA	TMLVTA	TMLVTA	TMLVTA	no
722	Kawich-Red	U-2cu	551	-181	no	36	370	298	442	TMLVTA	TMLVTA	TMLVTA	LCA3	yes
724	Palisade-1	U-4at	490	-155	no	37	335	261	409	TMLVTA	TMLVTA	TMLVTA	TMLVTA	yes
725	Palisade-2	U-4at	490	-100	yes	35	390	320	460	TMLVTA	TMLVTA	TMLVTA	TMLVTA	yes
726	Palisade-3	U-4at	490	-87	yes	35	404	334	474	TMLVTA	TMLVTA	TMLVTA	TMLVTA	yes
632	Caboc	U-2cp	522	-187	no	37	335	261	409	TMLVTA	TMWTA	TMLVTA	LCA3	yes
352	Cruet	U-2cn	523	-259	no	32	264	200	328	TMWTA	AA	TMLVTA	LCA3	yes

[a]USDOE, 2000b
[b]Derived from the Yucca Flat EarthVision® hydrostratigraphic model
[c]Calculated cavity radius from [70.2 * Max Yield$^{1/3}$ (kt)] / [overburden density (Mg/m^3) * WP depth (m)]$^{1/4}$, using yield from USDOE, 2000b
[d]LLNL Containment Data Base
[e]HSU information is derived from various data bases and/or the EarthVision® hydrostratigraphic model

Table 5.10 Categories of detonations for WPs located in western Areas 2 and 4.

ALL DETONATIONS	minus2Rc	3		1	3		14				1
	WP	3		1	17						1
	plus2Rc	2	1	1	1	2	9	1	1	3	1
SATURATED DETONATIONS	minus2Rc						4				
	WP						4				
	plus2Rc						2			2	
UNSATURATED DETONATIONS	minus2Rc	3		1	3		10				1
	WP	3		1	13						1
	plus2Rc	2	1	1	1	2	7	1	1	1	1

Legend (HSUs are identified in Table 1.2)

AA
TM-UVTA
UTCU
TM-WTA
TM-LVTA
LTCU
OSBCU
ATCU
MGCU
LCA3
LCA
UCCU
LCCU

Categories of detonations for WPs located in western Areas 2 and 4:

All detonations—10

Saturated detonations—2

Unsaturated detonations—10

5.3 Sites with Known Radionuclide Migration

As shown in Table 5.11, eight detonations in Yucca Flat were known to have caused radionuclide migration that was detected at a drill hole located nearby (DOE, 1992). These detonations fall outside the assumption that all radionuclides are initially deposited within the 2-Rc volume. Two additional detonations are included in the table to show that investigations subsequent to the report indicated no movement of radionuclides after initial deposition from the detonation, supporting the assumption of initial deposition within the 2-Rc volume. The following summary is taken from DOE (1992).

- AVENS-ANDORRE—Planned emplacement hole U-9 ITS U-29 was found to contain ^{192}Ir and a number of fission products in fractures at about 220–230 m deep. The origin of this material was believed to be from the unsaturated AVENS-ANDORRE detonation, detonated two months earlier at U-9 ITS T-28, which is 172 m away. Gamma logging, TV scanning, and sidewall sampling were used to associate the fractures and radioactive material. Two auxiliary holes were drilled to investigate and yielded core with ^{137}Cs. An additional hole drilled at a different orientation yielded no activity. Because the radioactivity was located well above the water level and had gotten there in a short amount of time, a prompt injection mechanism seems likely.

- NASH—Significant quantities of tritium and low but measurable amounts of ^{85}Kr, ^{22}Na, and ^{90}Sr have been detected in UE-2ce, a satellite well drilled into the Paleozoic carbonate aquifer 180 m from the NASH detonation. The satellite well was drilled ten years after detonation, and pumping was intermittent. Although NASH was detonated above the water table and is considered an unsaturated detonation, its cavity likely extends to a depth very near the water. Since the cavity does not intersect the water table, researchers concluded that radionuclides entered the water-bearing zone through prompt injection. They could not, however, eliminate the possibility that fluctuations in water level may have been sufficient to flood the existing cavity. It is also possible that nuclides were transported downward to the underlying water table by infiltration of surface water through the chimney and cavity. This is one of two cases at the NTS in which the regionally important carbonate aquifer has been affected by radionuclides (the other is UE-7nS, described below). Recent examination of data indicates the water table may have been closer to the WP than previously thought.

- LATIR—Core material from exploratory hole UE-4g#2 contained tritium and several fission products. The probable source was identified as the saturated detonation LATIR in U-4d, fired four years earlier 320 m to the northwest. Because of the strontium-to-tritium ratio in the core material, it has been argued that the transport was by gaseous krypton precursors, and the magnitude of the ^{89}Sr/^{90}Sr ratio further suggests that movement occurred no more than minutes after the LATIR detonation. These two facts make prompt injection a likely mechanism.

- BILBY—Radioactivity was detected on cores and well logs from U-3cn#5, a satellite hole drilled 122 m from BILBY, the first nuclear detonation fired below the water table. U-3cn#5 was drilled two years after detonation. Based on data from a BILBY reentry hole, the collapsed chimney had not yet refilled with water, and water movement at this time was towards the cavity. Because of this, the radioactivity could not have been transported from the cavity by normal groundwater movement but instead must have been injected through fractures during the detonation.

- SANDREEF—During dewatering in 1985 of the emplacement hole U-3kz for the ALEMAN detonation, the water was found to contain tritium and fission products (^{85}Kr, ^{106}Ru, ^{125}Sb, and ^{137}Cs). Ratio analysis enabled the source to be identified as the saturated detonation SANDREEF, conducted eight years earlier and 350 m away. Exploratory holes drilled between the two emplacement locations indicated that fission products occurred in narrow bands that were perhaps fractures. Tritium concentrations in water samples from the holes correlated well with the fission product concentrations. Laboratory studies of rock cores suggested that fission products in UE-3e#4 did not move to that location as dissolved species or with colloids moving in the groundwater. Based on this, prompt injection was the mechanism identified, but groundwater flow could not be eliminated as a transport mechanism. Also complicating the interpretation is the presence of a highly pressurized hydrologic zone near the bottom of the well (U-3kz is located in the Tuff Pile high-pressure zone).

- BOURBON—This saturated detonation occurred in 1967 in Paleozoic rocks approximately 22 m above the water level. It is probable that the cavity intersected the water table. In 1976, satellite well UE-7nS was drilled 138 m from the emplacement location. The cased well was perforated so that water could be sampled from approximately the top seventy meters of the pre-test saturated zone. Low-volume pumping took place until 1984. Maximum tritium levels detected during this time were about 3 pCi/mL, about 7 times lower than drinking water standards, but approximately 300 times greater than regional background levels. No other radionuclide contamination was detected in the water. It is significant to note that tritium levels increased throughout the duration of low volume pumping, implying migration through groundwater, rather than prompt injection alone. BOURBON is the second known site at the NTS where the regional carbonate aquifer has been affected by radionuclides.

- AGILE—In 1975 tritium concentrations of about $3x10^2$ pCi/mL were measured in water from UE-2ar; the source was thought to be the 1967 saturated AGILE detonation in U-2v, which is 360 m to the north. In 1986, an archived sample of water from UE-2ar was found to contain both ^{125}Sb and ^{137}Cs. Because ^{137}Cs is a highly sorbing nuclide, its presence in the water supports the belief that the tritium source was fairly close to UE-2ar. It was thought that groundwater movement caused the migration, but prompt injection may have also played a role.

- COMMODORE—Tritium concentrations up to $1x10^4$ pCi/mL was detected in 1974 in water pumped from U-2aw. No gamma-emitting fission products were detected. Tritium was also detected at this time in adjacent UE-2aw, but in lower concentrations. The probable source was thought to be the 1967 saturated Commodore detonation in U-2am 465 m to the southeast. COMMODORE was the closest detonation to U-2aw that was detonated beneath the water table.

These eight cases document radionuclide migration by prompt injection and groundwater movement. The same report (DOE, 1992) discusses several other examples in Frenchman Flat and Pahute Mesa. Also identified are three sites where radionuclide migration might have been expected to occur, but field investigations did not discover contamination.

More recent field activity has identified ER-02-5 on Pahute Mesa, where plutonium was observed 1300 m from the saturated BENHAM detonation (Kersting et al., 1999).

There are also documented examples in Yucca Flat where radionuclides have remained in place for a number of years. The following is summarized from Smith (1995). BASEBALL was executed in U-7ba in 1981. Post-test drilling and sampling of the cavity and chimney regions took place in1994, more than 10 years after detonation of this saturated detonation. Scientists concluded that the post-test distribution of radionuclides had not been significantly disturbed since immediately after zero time, that there was very little homogenization of even the volatile radionuclides, and that the tritium apparently had not migrated significantly. The INGOT detonation in U-2gg occurred in 1989. Post-test drilling and sampling of a limited region near the edge of the cavity of this saturated detonation indicated radionuclides limited to fractures associated with the explosion.

The above summaries from Yucca Flat detonations include saturated and unsaturated detonations that exhibited prompt injection and transport in groundwater. Other saturated detonations showed little disturbance of radionuclide deposition immediately after zero time. It is important to note that many other holes have been drilled near expended emplacement locations where no radiation was found. It is difficult to form generalities about the presence of radionuclides outside the cavity region, let alone to identify cause, based on the limited data at hand. Due to the fact that there are only two unclassified radionuclide inventories for Yucca Flat (one for saturated detonations, the other for unsaturated detonations—Bowen, 2001) that can be utilized for radionuclide transport modeling, it seems reasonable that we follow the simple conceptual model of radionuclides initially distributed within 2-Rc of a WP to permit UGTA to develop an unclassified contaminate boundary, essentially ignoring injection of radionuclides outside this volume. It may be necessary to investigate special cases, such as prompt injection, when classified modeling is performed and site-specific data can be used.

Table 5.11 Selected data for detonations in Yucca Flat with known radionuclide migration information.

YFDB ID	Detonation Name[a]/ Source of radionuclides[f]	Hole Name[a]	Water Level (WL) Depth[b] (m)	WP minus WL (m)	Sat deton-ation?	Calc Cavity Radius (Rc)[c] (m)	WP Depth[d] (m)	WP -2-Rc (m)	WP+2 -Rc (m)	WP HSU[e]	WP -2-Rc HSU[e]	WP +2-Rc HSU[e]	HSU at Water Table[e]	Collapse to surface[d]?	Location detected[f]	Process[f]	Surface distance[f] (m)
419	Avens-Andorre	U-9 ITS T-28	555	-176	no	35	379	309	449	LTCU	TMLVTA	LTCU	LCA	yes	U-9 ITS U-29	prompt injection	172
230	Nash	U-2ce	527	-163	no	45	364	274	454	LCA3	TMLVTA	LCA3	UCCU	yes	UE-2ce	prompt injection	180
503	Latir	U-4d	486	155	yes	67	641	507	775	LTCU	LTCU	OSBCU	LTCU	yes	UE-4ag#2 (Iceberg site)	prompt injection	320
97	Bilby	U-3cn	509	205	yes	70	714	574	854	OSBCU	LTCU	ATCU	LTCU	yes	UE-3cn#5	prompt injection	122
571	Sandreef	U-7aq	479	222	yes	60	701	581	821	LTCU	LTCU	LTCU	LTCU	yes	U-3kz (Aleman site)	prompt injection	350
231	Bourbon	U-7n	601	-41	yes	69	560	422	698	LCA	LTCU	LCA	LCA	no	UE-7nS	ground water	137
234	Agile	U-2v	543	190	yes	65	733	603	863	TMLVTA	TMWTA	LTCU	AA	yes	UE-2ar (Asiago site)	ground water	360
245	Commodore	U-2am	549	196	yes	69	745	607	883	LTCU	TMLVTA	OSBCU	LTCU	yes	UE-2aw (Stanyan site)	ground water	465
617	Baseball	U-7ba	458	105	yes	63	564	438	690	LTCU	LTCU	ATCU	LTCU	yes		No movement	
723	Ingot	U-2gg	564	-64	yes	65	500	370	630	TMWTA	AA	TMLVTA	TMLVTA	yes		No movement	

[a]USDOE, 2000b
[b]Derived from the Yucca Flat EarthVision® hydrostratigraphic model
[c]Calculated cavity radius from [70.2 * Max Yield$^{1/3}$ (kt)] / [overburden density (Mg/m^3) * WP depth (m)]$^{1/4}$, using yield from USDOE, 2000b
[d]LLNL Containment Data Base
[e]HSU information is derived from various data bases and/or the EarthVision® hydrostratigraphic model
[f]USDOE, 1992

5.4 Detonations with Zero Yield

Three detonations in Yucca Flat were announced as having zero yield (USDOE, 2000b)—SAN JUAN, COURSER, and TRANSOM. SAN JUAN was a safety experiment conducted in unstemmed hole U-3p in 1958. COURSER was a Joint US-UK detonation conducted in U-3do in 1964. TRANSOM, a weapons-related detonation, was emplaced in U-4f in 1978 but did not detonate. U-4n was drilled near U-4f, and HEARTS was detonated in 1979 to destroy the TRANSOM device.

Zero-yield detonations are an anomaly for radionuclide migration studies because they are included in the radiologic source term inventory (Bowen et al, 2001), but conceptually have no volume in which to place the inventory. The UGTA Project calculates cavity size using the announced yield (or the maximum of the announced yield range). This permits simple and direct unclassified volume determinations and has been assumed to be a conservative approach because it disperses the inventory over the largest volume possible for a given detonation at the start of transport simulations. Since these three detonations have zero yield, the standard procedure of calculating a cavity size based on yield has no merit. Modifying yields is not permitted by classification guidelines. In order to apply all inventory derived by Yucca Flat and Climax Mine detonations within the CAU modeling domain, the inventory should be divided between all tests with non-zero yield. This means that the Bowen radiological inventory should be divided between 744 tests, and SAN JUAN, COURSER, and TRANSOM will not appear as unique source release points. These three detonations occurred near other detonations, and contaminant transport paths should merge. This approach is consistent with classification guidelines, permits allocation of all Bowen inventory, and removes no unique source release points from the model.

6.0 Summary, Issues, Pre-emptive Review, Conclusions, and Recommendations

6.1 Summary

The task to collect, qualify, and evaluate data for 747 underground nuclear detonations in the Yucca Flat/Climax Mine CAU is described in this report. The objective of the work was to categorize detonations in order to:

(1) Reduce the number of detonations that must be individually modeled to develop source term boundary conditions for specific detonations and understand processes that contribute to radionuclide migration, and

(2) Understand the ranges of data and simplified process models that will be utilized in sensitivity studies addressing the source terms for all detonations to be applied in the CAU transport model.

This categorization of detonations task will benefit HST modeling, which combines nonisothermal hydrologic flow modeling and mechanistic geochemical modeling (rock-water-radionuclide interactions) to evaluate radionuclide release, retardation, and migration away from the cavity-chimney region in the near field of selected individual detonations. Categorization will also benefit SST modeling, which incorporates distributions of data to represent all detonations, or categories of detonations, in the CAU, and relies on the understanding and simplification of complex process models implemented during HST modeling. The simplified models are used to estimate the source term for all detonations individually in a CAU.

We have reviewed the pre-test and post-test settings, relationship of the WP to the SWL, and chemical environments to develop categories of detonations. Data include numbers of detonations, timing of executions between 1957 through 1992, locations in Yucca Flat and Climax Mine, purpose of the detonations, range of yields, relationship of the minus 2-Rc/WP/ plus 2-Rc volumes for each detonation hydrostratigraphic setting, grouped hydrostratigraphic units, projection WPs to the water table, and a number of special cases to determine if categories of detonations can be identified. The analysis has been complex due to the large size of the data set.

However, the most complicating factor is that the EarthVision® model was developed concurrently with the categorization of detonations. The EarthVision® model was the sole source of information on the 3-D geologic structure and hydrostratigraphic setting of each detonation. Categorization of tests on Pahute Mesa (Pawloski et al., 2002) and subsequent preparation for transport modeling clearly indicate the importance of data from the hydrostratigraphic model. A significant amount of work was undertaken to qualify the data used in this study. But because the EarthVision® model was not completely qualified and peer-reviewed when the categorization of detonations task began, a “preliminary” label must be applied to these results. Additional work must be done with the qualified and peer-reviewed model to assure that conclusions derived form the preliminary model are still applicable, and determine if new conclusions can be developed.

On a positive note, data independent of the hydrostratigraphic model are valid as evaluated and described in this report. Thus, conclusions on timing, locations, purpose, and yields of detonations have merit, as shown in Chapter 2. However, categories were not formed from these parameters, mainly because tests were located based on yield and fielding and operational criteria for the weapons program at given points in time (e.g., nearness to support facilities, balancing resources, ground shock interactions). Thus these parameters have correlations not important to task goals included in them at inception.

The pre-test information, which includes HSUs and mineral compositions, and post-test settings, which capture 2-Rc volumes for saturated and unsaturated detonations, provide the most information for categorizing detonations for this CAU. As shown in Chapter 2, it is clear that categorizing of detonations in the Yucca Flat/Climax Mine CAU based on HSUs in the 2-Rc volumes reduces the total number of detonations for which source terms must be calculated. Mineral composition of the HSUs in the 2-Rc volumes (alluvium vs. vitric tuff vs. altered tuff vs. carbonate vs. granitic rock) will affect chemical reactions.

The projection of WPs to the water table places a large number of unsaturated detonations (about one quarter of all unsaturated detonation) directly into the regional carbonate aquifer (Chapter 3). It seems unreasonable to take this simplistic approach because it doesn’t take into account slow release and migration of radionuclides in the partially saturated environment that hosts these detonations, nor the potential of any retardation between the WP and regional carbonate aquifer. Source term release from an unsaturated detonation must be modeled based on the true host environment, then transport to the regional carbonate aquifer using realistic assumptions about infiltration rates and retardation can be applied. It is expected that the reevaluation of categories formed in Chapters 3 and 4 will not change significantly and the current results can be discussed illustratively.

Special cases were reviewed to determine if categories of detonations that would supercede conclusions drawn in Chapter 3 could be identified for simultaneously detonated detonations or detonations in particular regions. Chapter 5 investigates simultaneous detonations; regions including the Area 9 ITS region, the Sand Pile, the Tuff Pile, and western Areas 2 and 4; areas of known radionuclide migration; and detonations in Yucca Flat with zero yield.

6.2 Issues

Issues remain. Foremost, the EarthVision® model needs to be qualified and HSU “lines” need to be developed for each detonation, identifying from the ground surface above the WP to the carbonate aquifer or the water table, whichever is deepest. The lines must identify each HSU in stratigraphic order and the associated depth. These HSU lines will be useful to investigate many questions, such as reevaluation of categories for the 2-Rc volumes; investigation of potential elimination of detonations from the calculated source term because of distance of the WP to the surface (will recharge reach the WP?) or distance of the WP to the water table (will recharge reaching the WP contribute to the water table?); and determination of the extent of the TCU in the testing areas and its impact on source term and transport modeling. The qualified EV model should also be used to evaluate, in a 3-D sense, the closeness of cavities for simultaneous detonations in the same hole, and develop an understanding if geologic structure provides shortcuts between the WP regions and the water table, or between saturated aquifers, that could enhance transport of radionuclides.

Several issues are identified that will benefit from further program discussion. A procedure needs to be developed for calculating the source term for detonations where the minus 2-Rc/WP/plus 2-Rc volume is unsaturated or only partially saturated. We need to determine how to initially partition radionuclides in the 2-Rc volume, and how groundwater flux in the unsaturated zone can mobilize radionuclides and contribute source term to the saturated zone. Associated with this is the determination of how to project radionuclide source from an unsaturated detonation to the water table. It is important to consider the hydrologic and sorptive properties of the host rock when calculating mobility of radionuclides. This requires calculating the source term at the true WP depth. Projecting that source term directly to the water table may take a programmatically conservative approach of introducing as much source term as possible into the water table, but it may not be a realistic approach when the source term for one quarter of the unsaturated detonations will be placed immediately into the regional carbonate aquifer. Imprinted on these issues is the question related to elimination of detonations. Are there times when detonations in the unsaturated zone are so far from or so isolated from the saturated zone that they will not naturally contribute to the source term and should not be included when modeling the contaminant boundary? These issues are important for the Yucca Flat/Climax Mine CAU because of the large number of detonations that are affected. It is important to resolve the issues now to permit subsequent work to undertaken as realistically as possible within program concerns.

6.3 Pre-emptive Review

The UGTA Project has formed pre-emptive review groups to address the adequacy, feasibility, and prioritization of the technical work and to advocate alternate methods and strategies, as necessary, to meet technical objectives. The intent of pre-emptive reviews is to provide real-time input to the work process so the final product meets program goals in a reasonable amount of time. A pre-emptive review group was formed for the Yucca Flat/Climax Mine CAU HST and SST. Much of the information in this report was presented at their first meeting in November 2005. The review group was intrigued by the analysis, provided significant discussion on concepts developed, and identified weaknesses that need correcting to maximize value to the Project.

The group agreed it was possible to reduce the total number of detonations to be considered by categorization based on HSUs within the 2-Rc volume. Because this could reduce the total number of detonations for which a source term must be calculated, the categorization based on HSUs would be of most value to simplified source term modeling. Obtaining HSU data from the qualified EarthVision® model was of high importance. Fortunately Bechtel Nevada is in the process of resolving review comments for the model and this issue should be closed soon.

The group recognized inconsistencies with saturated and unsaturated detonation definitions. Currently, a detonation with a WP as much as 100 m above the water level could be identified as a saturated detonation. While this makes it easier to discuss in unclassified terms if a detonation might have affected the water table in regards to cavity growth and radionuclide distribution, it is very unsatisfactory in conceptualizing whether the 2-Rc volume is truly saturated for flow and transport calculations. Of the 747 detonations in Yucca Flat and Climax Mine, 170 detonations are identified as saturated and 577 detonations are unsaturated. Reviewing WP water level configurations, 670 detonations had a WP above the water table, and the bottom of the 2-Rc volume for 577 detonations was above the water table (the latter included 16 detonations identified as saturated detonations). However, the unclassified inventory is calculated for two sets of tests—and only two sets of tests—for the Yucca Flat/Climax Mine CAU (Bowen et al., 2001), so we must utilize this “saturated detonation” definition to properly assign the radionuclide inventory in the 2-Rc volume.

To date the UGTA Project has assumed that the 2-Rc volume for all detonations is saturated. This is considered a conservative assumption that places all radionuclide inventory in the groundwater and makes it immediately available for transport, providing the largest possible extent of contamination. The assumption that the entire 2-Rc volume is saturated affects how radionuclides are initially partitioned within the 2-Rc volume, which has been based on comprehensive studies of underground nuclear tests (IAEA work noted in Tompson et al., 1999 and Pawloski et al., 2001). This issue is related to early-time phenomenological processes in the cavity and chimney and can best be investigated by detailed hydrologic source term modeling.

Issues remain on unsaturated to partially saturated 2-Rc volumes and how to generate water flux that has potential to contribute to mobilization of radionuclides. Recharge data should be investigated to determine flux rates that can be applied to the various HSUs above unsaturated WPs (for example, Stoller-Navarro, 2006). The affect of a surface collapse crater and its ability to preferentially direct precipitation into the collapse chimney and downward to the cavity region has been investigated by Desert Research Institute (Hockett et al., 2000 and Hockett et al., 1998) and should be included. Analytical application of flux rates may help determine if water in the unsaturated zone can reach the 2-Rc volume to mobilize radionuclides. Hydrologic source term or simplified analytical modeling will be needed to understand the impact of unsaturated to partially saturated conditions on radionuclide migration.

The idea of projecting the radionuclide source to the water table for unsaturated detonations is another difficult concept to accept. All reviewers agreed that the source term should be calculated in the true HSU setting where the WP was located (where the device was detonated) rather than projecting the WP to the water table and calculating the source term at the new HSU setting. This will incorporate realistic application of hydrologic and geochemical properties. Because it affects so many detonations and immediately affects the carbonate aquifer, the programmatic assumption of placing all source term immediately in groundwater requires evaluation for Yucca Flat. If significant distance exists between the WP and the water table, radionuclides may never reach the saturated zone. The EarthVision® model shows that the unsaturated WPs for 133 detonations would project to the carbonate aquifer at the water table. While it would absolutely be the worst case scenario to dump the source term from these detonations into the aquifer, it is questionable that this is a technically conservative approach. Perhaps insufficient infiltration exists for these detonations to contribute to downward migration to the carbonate aquifer. Analytical investigation of water fluxes through the unsaturated and partially saturated zones, including potential for preferential recharge via collapse craters, should address this issue. Perhaps the tuff confining unit (TCU) will retard the migrating radionuclides and they would never reach the saturated carbonate aquifer. It seems technically unreasonable to take no "credit" for the distance from the WP to the water table that reactive transport would have to occur in and through, and the relatively high sorbing capability of the TCU, the final unit(s) stratigraphically above the carbonate rocks. These issues may be best investigated by hydrologic source term or simplified analytical modeling.

UGTA source term simulations to date have included radionuclide migration in alluvium and tuff. Hydrologic source terms have been simulated for alluvium and fractured tuff. We have not investigated reactive transport in carbonate rocks, where we know flow velocities and sorptive properties will affect radionuclide release and retardation (Ware et al., 2005). We know the phenomenology of detonations in carbonate rocks will be different from silicate rocks because of chemistry and rock strength, but we don't know how that will affect initial radionuclide distribution in the 2-Rc volume, the properties of the melt glass, and the flow and transport mechanisms specific to this rock type. These issues are best investigated by hydrologic source term modeling.

The pre-emptive review group saw a need to have this report released to UGTA Project members as soon as possible to assist in future work, recognizing further work was necessary and could be accomplished as part of the transport parameters analysis task. Thus this report provides a structure for further evaluations and a framework of issues that should be discussed and resolved.

6.4 Conclusions

Even with limitations resulting from the concurrent development of the EarthVision® model and the categorization of detonations task, conclusions can be drawn that permit work to proceed.

(1) Data on timing, locations, purpose, and yields of detonations shown in Chapter 2.

(2) Chapter 3 shows that categories of detonations can be developed using HSUs in the 2-Rc volume. Various tables in this chapter identify combinations of HSUs and the numbers of categories for WPs in a given HSU, while Table 3.13 summarizes this information for all WP HSUs. Table 3.19 summarizes information for grouping vitric tuffs, altered tuffs, and carbonate rocks. Grouping provided minor modifications to the numbers of categories developed based on HSUs in the 2-Rc volume. The value of grouping HSUs must be investigated. All of this information must be updated using the qualified EarthVision® model.

(3) Projecting the unsaturated WP to the water table provided interesting information to help address the issue of assuming the source term from all detonations contribute to the water table and radionuclides should be placed at the water table for immediate release. Various figures in Chapter 3 show the locations of saturated detonations for a given HSU, and also plot the locations of unsaturated detonations that would project to the given HSU at the water table. Tables 3.1 and 3.2 show (as expected) that projecting WPs to the water table increases the numbers of detonations at a given HSU at the water table, even if saturated detonations were already located in that HSU. Projecting a WP to the water table does not take into consideration proceses related to infiltration or sorption that could delay or eliminate radionuclide transport to the water table within the 1,000 year regulatory period. All of this information must be updated using the qualified EarthVision® model.

(4) Special cases were reviewed to determine if categories of detonations that would supercede conclusions drawn in Chapter 3 could be identified for simultaneously detonated detonations or detonations in particular regions. Simultaneous detonations in separate holes should be treated the same as any other detonations. Some simultaneous detonations in the same hole, as well as detonations that were considered as a different test but were detonated within a hole with another test can be grouped (Table 5.2). Notes in Table 5.1 provide comments on distributing radionuclide inventory. Categories can be formed for detonations in the Area 9 ITS region (Table 5.4), the Sand Pile (Table 5.6), and the Tuff Pile (Table 5.8). Areas of known radionuclide migration should not affect how radionuclide inventory is initially distributed in the 2-Rc volume. The three detonations in Yucca Flat with zero yield should be removed from transport simulations and their inventory allocated to the other tests by dividing the Bowen et al. inventory by 744 rather than 747 detonations.

Finally, work accomplished in this report provides insight that affects both hydrologic source term (HST) and simplified source term (SST) modeling efforts.

(1) Simplified source term modeling for all detonations in the CAU can be reduced by developing categories of detonations as outlined in Chapters 3 and 5. Analytical approaches used in SST modeling can be applied to determine flux in the unsaturated zone that contributes to mobilizing radionuclides, and the impact of the TCU on restraining radionuclides located above or within this HSU and thus restricting their contribution to the saturated zone. Results from these analytical methods may permit elimination of detonations from transport calculations.

(2) Hydrologic source term models are needed to address issues new to the program. This includes understanding how the source term is developed for detonations sited in carbonate rock, the capability of the TCU to restrain radionuclides located above or within the HSU, thus restricting their

contribution to the saturated zone, and the ability of detonations above the water table to contribute source term to the saturated zone.

6.5 Recommendations

The following recommendations are made based on the categorization of detonations task:

1) The EarthVision® model must be qualified and HSU “lines” need to be assembled for each detonation from the ground surface to the carbonate aquifer or the water table, whichever is deeper. These lines need to be evaluated to update categories developed for WP HSUs in Chapter 3.

2) The qualified EarthVision® model should be used to review in 3-D potential for overlap of 2-Rc volumes for closely located detonations. This may affect how radionuclide inventory is distributed in the 2-Rc volumes. The model should also be used to determine if shortcuts (faults that juxtapose aquifers not normally positioned near each other) exist that will permit radionuclides to reach saturated aquifers faster than if no short cuts exist.

3) The HSU lines should also be used to investigate possible elimination of detonations if the distance from the ground surface (or bottom of the collapse crater) to the water table can not contribute sufficient water to mobilize radionculides or contribute source term to the water table.

4) The qualified EarthVision® model should be evaluated to determine the presence and extent of the tuff confining unit in testing areas. Minerals in the TCU have been shown to significantly retard radionuclide migration. The larger the extent of the TCU, both horizontally and vertically, the larger impact it will have on migration. An important part of this review is that is must be accomplished in 3 dimensions to determine if faults provide shortcuts through the TCU.

5) The hydrologic source term produced from a detonation located in carbonate rock needs to be developed and understood, since this work has not be undertaken to date. Attention should focus on the initial distribution of the radionuclide inventory, the release and retardation of radionculides, and the affect of saturation on geochemical and flow processes. Understanding developed from HST modeling will be useful in simplifying process models for use in (SST) modeling.

6) Several issues were identified pertaining to detonations where the 2-Rc volume is unsaturated or only partially saturated. This issue is common to all CAUs, but particularly important to the Yucca Flat/Climax Mine CAU because of the large number of detonations that are located in the unsaturated zone. The same issue will also be important to the Rainier Mesa/Shoshone Mountain CAU where all detonations were located above the regional water

table. UGTA participants should work with the DOE UGTA Project Manager to evaluate the following issues:

a. The impact of projecting the source term from unsaturated or partially saturated detonations directly into the saturated zone.

b. Development of a procedure that will quantify the flux that mobilizes radionuclides in the unsaturated or partially saturated zone.

c. Criteria to eliminate detonations that do not contribute to the source term in the saturated zone.

7) Desert Research Institute should continue sub-CAU modeling efforts currently underway at the Climax Stock. Their models are expected to evaluate the impact of groundwater flow into the Yucca Flat basin from the north and radionuclide release and migration from the detonations in the stock into the Yucca Flat basin.

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Appendix A

Selected information for underground nuclear detonations in shafts and tunnels in the Yucca Flat /Climax Mine CAU, sorted by detonation date.

Detonation Name[a]	Hole Name[a]	Detonation Date[a]	Emplacement Type[a]	Purpose[a]	Announced Yield[a] (kt)	Max Yield (kt)	Comment[a,b]	Known radionuclide migration[e]
Pascal-A	U-3j	7/26/57	Shaft	Safety Experiment	Slight	20		
Pascal-B	U-3d	8/27/57	Shaft	Safety Experiment	Slight	20		
Pascal-C	U-3e	12/6/57	Shaft	Safety Experiment	Slight	20		
Otero	U-3q	9/12/58	Shaft	Safety Experiment	38 tons	0.038		
Bernalillo	U-3n	9/17/58	Shaft	Safety Experiment	15 tons	0.015	Radioactivity not detected offsite	
Luna	U-3m	9/21/58	Shaft	Safety Experiment	1.5 tons	0.0015	Radioactivity not detected offsite	
Valencia	U-3r	9/26/58	Shaft	Safety Experiment	2 tons	0.002	Radioactivity not detected offsite	
Colfax	U-3k	10/5/58	Shaft	Safety Experiment	5.5 tons	0.0055	Radioactivity not detected offsite	
San Juan	U-3p	10/20/58	Shaft	Safety Experiment	Zero	0		
Shrew	U-3ac	9/16/61	Shaft	Weapons Related	Low	20	Accidental release of radioactivity detected onsite only	
Boomer	U-3aa	10/1/61	Shaft	Weapons Related	Low	20	Accidental release of radioactivity detected onsite only	
Mink	U-3ae	10/29/61	Shaft	Weapons Related	Low	20	Accidental release of radioactivity detected onsite only	
Fisher	U-3ah	12/3/61	Shaft	Weapons Related	13.4 kt	13.4	Accidental release of radioactivity detected onsite only	
Mad	U-9a	12/13/61	Shaft	Weapons Related	500 tons	0.5	Accidental release of radioactivity detected onsite only	
Ringtail	U-3ak	12/17/61	Shaft	Weapons Related	Low	20	Accidental release of radioactivity detected onsite only	
Stoat	U-3ap	1/9/62	Shaft	Weapons Related	5.1 kt	5.1	Accidental release of radioactivity detected onsite only	
Agouti	U-3ao	1/18/62	Shaft	Weapons Related	6.4 kt	6.4		
Dormouse	U-3aq	1/30/62	Shaft	Weapons Related	Low	20	Accidental release of radioactivity detected onsite only	
Stillwater	U-9c	2/8/62	Shaft	Weapons Related	3.07 kt	3.07		
Armadillo	U-3ar	2/9/62	Shaft	Weapons Related	7.1 kt	7.1	Accidental release of radioactivity detected onsite only	
Hard Hat	U-15a	2/15/62	Shaft	Weapons Effects	5.7 kt	5.7	Accidental release of radioactivity detected onsite only	
Chinchilla	U-3ag	2/19/62	Shaft	Weapons Related	1.9 kt	1.9	Accidental release of radioactivity detected onsite only	
Codsaw	U-9g	2/19/62	Shaft	Weapons Related	Low	20	Accidental release of radioactivity detected onsite only	
Cimarron	U-9h	2/23/62	Shaft	Weapons Related	11.9 kt	11.9		
Platypus	U-3ad	2/24/62	Shaft	Weapons Related	Low	20	Accidental release of radioactivity detected onsite only	
Pampas	U-3aL	3/1/62	Shaft	Joint US-UK	9.5 kt	9.5	Accidental release of radioactivity detected offsite	
Ermine	U-3ab	3/6/62	Shaft	Safety Experiment	Low	20		
Brazos	U-9d	3/8/62	Shaft	Weapons Related	8.4 kt	8.4	Accidental release of radioactivity detected onsite only	
Hognose	U-3ai	3/15/62	Shaft	Weapons Related	Low	20		
Hoosic	U-9j	3/28/62	Shaft	Weapons Related	3.4 kt	3.4		
Chinchilla II	U-3as	3/31/62	Shaft	Weapons Related	Low	20	Accidental release of radioactivity detected onsite only	
Dormouse Prime	U-3az	4/5/62	Shaft	Weapons Related	10.6 kt	10.6		
Passaic	U-9L	4/6/62	Shaft	Weapons Related	Low	20		
Hudson	U-9n	4/12/62	Shaft	Weapons Related	Low	20		
Dead	U-9k	4/21/62	Shaft	Weapons Related	Low	20		
Black	U-9p	4/27/62	Shaft	Weapons Related	Low	20		
Paca	U-3ax	5/7/62	Shaft	Weapons Related	Low	20	Accidental release of radioactivity detected onsite only	
Arikaree	U-9r	5/10/62	Shaft	Weapons Related	Low	20		
Aardvark	U-3amS	5/12/62	Shaft	Weapons Related	40 kt	40	Accidental release of radioactivity detected onsite only	
Eel	U-9m	5/19/62	Shaft	Weapons Related	4.5 kt	4.5	Accidental release of radioactivity detected offsite	

Detonation Name[a]	Hole Name[a]	Detonation Date[a]	Emplacement Type[a]	Purpose[a]	Announced Yield[a] (kt)	Max Yield (kt)	Comment[a,b]	Known radionuclide migration[e]
White	U-9b	5/25/62	Shaft	Weapons Related	Low	20		
Raccoon	U-3ajS	6/1/62	Shaft	Weapons Related	Low	20		
Packrat	U-3aw	6/6/62	Shaft	Weapons Related	Low	20		
Daman I	U-3be	6/21/62	Shaft	Weapons Related	Low	20		
Haymaker	U-3au	6/27/62	Shaft	Weapons Related	67 kt	67	Accidental release of radioactivity detected onsite only	
Sacramento	U-9v	6/30/62	Shaft	Weapons Related	Low	20		
Merrimac	U-3bd	7/13/62	Shaft	Weapons Related	Intermediate	200	Accidental release of radioactivity detected onsite only	
Wichita	U-9y	7/27/62	Shaft	Weapons Related	Low	20	Accidental release of radioactivity detected onsite only	
Bobac	U-3bL	8/24/62	Shaft	Weapons Related	Low	20		
York	U-9z	8/24/62	Shaft	Weapons Related	Low	20		
Raritan	U-9u	9/6/62	Shaft	Weapons Related	Low	20		
Hyrax	U-3bh	9/14/62	Shaft	Weapons Related	Low	20		
Peba	U-3bb	9/20/62	Shaft	Weapons Related	Low	20		
Allegheny	U-9x	9/29/62	Shaft	Weapons Related	Low	20	Accidental release of radioactivity detected onsite only	
Mississippi	U-9ad	10/5/62	Shaft	Weapons Related	115 kt	115		
Roanoke	U-9q	10/12/62	Shaft	Weapons Related	Low	20	Accidental release of radioactivity detected onsite only	
Wolverine	U-3av	10/12/62	Shaft	Weapons Related	Low	20	Accidental release of radioactivity detected onsite only	
Tioga	U-9f	10/18/62	Shaft	Weapons Related	Low	20		
Bandicoot	U-3bj	10/19/62	Shaft	Weapons Related	12.5 kt	12.5	Accidental release of radioactivity detected offsite	
Santee	U-10f	10/27/62	Shaft	Weapons Related	Low	20		
St. Lawrence	U-2b	11/9/62	Shaft	Weapons Related	Low	20	Accidental release of radioactivity detected onsite only	
Gundi	U-3bm	11/15/62	Shaft	Weapons Related	Low	20		
Anacostia	U-9i	11/27/62	Shaft	Plowshare	5.2 kt	5.2	Accidental release of radioactivity detected onsite only	
Taunton	U-9aa	12/4/62	Shaft	Weapons Related	Low	20		
Tendrac	U-3ba	12/7/62	Shaft	Joint US-UK	Low	20		
Numbat	U-3bu	12/12/62	Shaft	Weapons Related	Low	20		
Manatee	U-9af	12/14/62	Shaft	Weapons Related	Low	20		
Acushi	U-3bg	2/8/63	Shaft	Weapons Related	Low	20		
Casselman	U-10g	2/8/63	Shaft	Weapons Related	Low	20		
Ferret	U-3bf	2/8/63	Shaft	Weapons Related	Low	20		
Hatchie	U-9e	2/8/63	Shaft	Weapons Related	Low	20		
Chipmunk	U-3ay	2/15/63	Shaft	Safety Experiment	Low	20		
Carmel	U-2h	2/21/63	Shaft	Weapons Related	Low	20		
Kaweah	U-9ab	2/21/63	Shaft	Plowshare	3 kt	3		
Jerboa	U-3at	3/1/63	Shaft	Weapons Related	Low	20		
Toyah	U-9ac	3/15/63	Shaft	Weapons Related	Low	20		
Gerbil	U-3bp	3/29/63	Shaft	Weapons Related	Low	20		
Ferret Prime	U-3by	4/5/63	Shaft	Weapons Related	Low	20		
Coypu	U-3af	4/10/63	Shaft	Safety Experiment	Low	20		
Cumberland	U-2e	4/11/63	Shaft	Weapons Related	Low	20		

Detonation Name[a]	Hole Name[a]	Detonation Date[a]	Emplacement Type[a]	Purpose[a]	Announced Yield[a] (kt)	Max Yield (kt)	Comment[a,b]	Known radionuclide migration[e]
Kootanai	U-9w	4/24/63	Shaft	Weapons Related	Low	20	Accidental release of radioactivity detected onsite only	
Paisano	U-9w #1	4/24/63	Shaft	Weapons Related	Low	20	Accidental release of radioactivity detected onsite only	
Gundi Prime	U-3db	5/9/63	Shaft	Weapons Related	Low	20		
Harkee	U-3bv	5/17/63	Shaft	Weapons Related	Low	20		
Tejon	U-3cg	5/17/63	Shaft	Safety Experiment	Low	20		
Stones	U-9ae	5/22/63	Shaft	Weapons Related	Intermediate	200		
Pleasant	U-9ah	5/29/63	Shaft	Weapons Related	Low	20	Accidental release of radioactivity detected onsite only	
Apshapa	U-9ai	6/6/63	Shaft	Weapons Related	Low	20	Accidental release of radioactivity detected onsite only	
Hutia	U-3bc	6/6/63	Shaft	Weapons Related	Low	20		
Mataco	U-3bk	6/14/63	Shaft	Weapons Related	Low	20		
Kennebec	U-2af	6/25/63	Shaft	Weapons Related	Low	20	Accidental release of radioactivity detected onsite only	
Pekan	U-3bw	8/12/63	Shaft	Weapons Related	Low	20		
Satsop	U-2g	8/15/63	Shaft	Weapons Related	Low	20		
Kohocton	U-9ak	8/23/63	Shaft	Weapons Related	Low	20	Silmultaneous, separate holes	
Natches	U-9ak #1	8/23/63	Shaft	Weapons Related	Low	20	Silmultaneous, separate holes	
Bilby	U-3cn	9/13/63	Shaft	Weapons Related	249 kt	249		Prompt injection to U-3cn #5
Ahtanum	U-2L	9/13/63	Shaft	Weapons Related	Low	20		
Carp	U-3cb	9/27/63	Shaft	Weapons Related	Low	20		
Narraguagus	U-2f	9/27/63	Shaft	Weapons Related	Low	20		
Grunion	U-3bz	10/11/63	Shaft	Weapons Related	Low	20		
Tornillo	U-9aq	10/11/63	Shaft	Plowshare	380 tons	0.38		
Mullet	U-2ag	10/17/63	Shaft	Safety Experiment	Low	20		
Anchovy	U-3bq	11/14/63	Shaft	Weapons Related	Low	20	Accidental release of radioactivity detected onsite only	
Mustang	U-9at	11/15/63	Shaft	Weapons Related	Low	20		
Greys	U-9ax	11/22/63	Shaft	Weapons Related	Intermediate	200		
Barracuda	U-3cr	12/4/63	Shaft	Weapons Related	Low	20	Sim, sep; Accidental release of radioactivity detected onsite only	
Sardine	U-3ch	12/4/63	Shaft	Weapons Related	Low	20	Sim, sep; Accidental release of radioactivity detected onsite only	
Eagle	U-9av	12/12/63	Shaft	Weapons Related	5.3 kt	5.3	Accidental release of radioactivity detected offsite	
Tuna	U-3de	12/20/63	Shaft	Weapons Related	Low	20	Accidental release of radioactivity detected onsite only	
Fore	U-9ao	1/16/64	Shaft	Weapons Related	20 to 200 kt	200		
Oconto	U-9ay	1/23/64	Shaft	Weapons Related	10.5 kt	10.5	Accidental release of radioactivity detected offsite	
Club	U-2aa	1/30/64	Shaft	Weapons Related	Less than 20 kt	20	Accidental release of radioactivity detected onsite only	
Solendon	U-3cz	2/12/64	Shaft	Weapons Related	Less than 20 kt	20	Accidental release of radioactivity detected onsite only	
Bunker	U-9bb	2/13/64	Shaft	Weapons Related	Less than 20 kt	20	Accidental release of radioactivity detected onsite only	
Bonefish	U-3bt	2/18/64	Shaft	Weapons Related	Less than 20 kt	20		
Mackerel	U-4b	2/18/64	Shaft	Weapons Related	Less than 20 kt	20		
Klickitat	U-10e	2/20/64	Shaft	Plowshare	70 kt	70		
Handicap	U-9ba	3/12/64	Shaft	Weapons Related	Less than 20 kt	20	Accidental release of radioactivity detected onsite only	
Pike	U-3cy	3/13/64	Shaft	Weapons Related	Less than 20 kt	20	Accidental release of radioactivity detected offsite	
Hook	U-9bc	4/14/64	Shaft	Weapons Related	Less than 20 kt	20	Accidental release of radioactivity detected onsite only	

Detonation Name[a]	Hole Name[a]	Detonation Date[a]	Emplacement Type[a]	Purpose[a]	Announced Yield[a] (kt)	Max Yield (kt)	Comment[a,b]	Known radionuclide migration[e]
Sturgeon	U-3bo	4/15/64	Shaft	Weapons Related	Less than 20 kt	20		
Bogey	U-9au	4/17/64	Shaft	Weapons Related	Less than 20 kt	20	Accidental release of radioactivity detected onsite only	
Turf	U-10c	4/24/64	Shaft	Weapons Related	20 to 200 kt	200		
Pipefish	U-3co	4/29/64	Shaft	Weapons Related	Less than 20 kt	20	Accidental release of radioactivity detected onsite only	
Driver	U-9ar	5/7/64	Shaft	Weapons Related	Less than 20 kt	20	Accidental release of radioactivity detected onsite only	
Backswing	U-9aw	5/14/64	Shaft	Weapons Related	Less than 20 kt	20	Accidental release of radioactivity detected onsite only	
Minnow	U-3cv	5/15/64	Shaft	Weapons Related	Less than 20 kt	20		
Ace	U-2n	6/11/64	Shaft	Plowshare	3 kt	3	Accidental release of radioactivity detected onsite only	
Bitterling	U-3cu	6/12/64	Shaft	Weapons Related	Less than 20 kt	20		
Duffer	U-10dS	6/18/64	Shaft	Weapons Related	Less than 20 kt	20		
Fade	U-9be	6/25/64	Shaft	Weapons Related	Less than 20 kt	20	Accidental release of radioactivity detected onsite only	
Dub	U-10a	6/30/64	Shaft	Plowshare	11.7 kt	11.7	Accidental release of radioactivity detected onsite only	
Bye	U-10i	7/16/64	Shaft	Weapons Related	20 to 200 kt	200		
Cormorant	U-3df	7/17/64	Shaft	Joint US-UK	Less than 20 kt	20	Accidental release of radioactivity detected onsite only	
Links	U-9bf	7/23/64	Shaft	Weapons Related	Less than 20 kt	20	Accidental release of radioactivity detected onsite only	
Trogon	U-3dj	7/24/64	Shaft	Weapons Related	Less than 20 kt	20		
Alva	U-2j	8/19/64	Shaft	Weapons Related	4.4 kt	4.4	Accidental release of radioactivity detected offsite by aircraft only	
Canvasback	U-3cp	8/22/64	Shaft	Weapons Related	Less than 20 kt	20		
Player	U-9cc	8/27/64	Shaft	Safety Experiment	Less than 20 kt	20		
Haddock	U-3dL	8/28/64	Shaft	Weapons Related	Less than 20 kt	20		
Guanay	U-3di	9/4/64	Shaft	Weapons Related	Less than 20 kt	20		
Spoon	U-9bd	9/11/64	Shaft	Weapons Related	Less than 20 kt	20		
Courser	U-3do	9/25/64	Shaft	Joint US-UK	0	0		
Auk	U-7b	10/2/64	Shaft	Weapons Related	Less than 20 kt	20		
Par	U-2p	10/9/64	Shaft	Plowshare	38 kt	38		
Barbel	U-3bx	10/16/64	Shaft	Weapons Related	Less than 20 kt	20	Silmultaneous, separate holes	
Turnstone	U-3dt	10/16/64	Shaft	Weapons Related	Less than 20 kt	20	Silmultaneous, separate holes	
Garden	U-9aj	10/23/64	Shaft	Weapons Related	Less than 20 kt	20		
Forest	U-7a	10/31/64	Shaft	Weapons Related	Less than 20 kt	20		
Handcar	U-10b	11/5/64	Shaft	Plowshare	12 kt	12	Accidental release of radioactivity detected onsite only	
Drill (Source-Lower)	U-2ai	12/5/64	Shaft	Weapons Related	3.4 kt	3.4	Sim, same; Accidental release of radioactivity detected offsite	
Drill (Target-Upper)	U-2ai	12/5/64	Shaft	Weapons Related	Less than 20 kt	20	Sim, same; Accidental release of radioactivity detected offsite	
Crepe	U-2q	12/5/64	Shaft	Weapons Related	20 to 200 kt	200		
Parrot	U-3dk	12/16/64	Shaft	Weapons Related	1.3 kt	1.3	Accidental release of radioactivity detected offsite	
Cassowary	U-3bn	12/16/64	Shaft	Weapons Related	Less than 20 kt	20	Silmultaneous, separate holes	
Hoopoe	U-3cf	12/16/64	Shaft	Safety Experiment	Less than 20 kt	20	Silmultaneous, separate holes	
Mudpack	U-10n	12/16/64	Shaft	Weapons Effects	2.7 kt	2.7		
Wool	U-9bh	1/14/65	Shaft	Weapons Related	Less than 20 kt	20		
Tern	U-3dw	1/29/65	Shaft	Weapons Related	Less than 20 kt	20	Accidental release of radioactivity detected onsite only	
Cashmere	U-2ad	2/4/65	Shaft	Weapons Related	Less than 20 kt	20		

Detonation Name[a]	Hole Name[a]	Detonation Date[a]	Emplacement Type[a]	Purpose[a]	Announced Yield[a] (kt)	Max Yield (kt)	Comment[a,b]	Known radionuclide migration[e]
Alpaca	U-2a	2/12/65	Shaft	Weapons Related	330 tons	0.33	Accidental release of radioactivity detected offsite	
Merlin	U-3ct	2/16/65	Shaft	Weapons Related	10.1 kt	10.1	Accidental release of radioactivity detected onsite only	
Seersucker	U-9bm	2/19/65	Shaft	Weapons Related	Less than 20 kt	20	Accidental release of radioactivity detected onsite only	
Wagtail	U-3an	3/3/65	Shaft	Weapons Related	20 to 200 kt	200		
Suede	U-9bk	3/20/65	Shaft	Weapons Related	Less than 20 kt	20		
Cup	U-9cb	3/26/65	Shaft	Weapons Related	20 to 200 kt	200		
Kestrel	U-3dd	4/5/65	Shaft	Weapons Related	Less than 20 kt	20		
Chenille	U-9bg	4/22/65	Shaft	Weapons Related	Less than 20 kt	20	Accidental release of radioactivity detected onsite only	
Muscovy	U-3dx	4/23/65	Shaft	Weapons Related	Less than 20 kt	20		
Tee	U-2ab	5/7/65	Shaft	Weapons Effects	7 kt	7	Accidental release of radioactivity detected offsite	
Scaup	U-3daS	5/14/65	Shaft	Weapons Related	Less than 20 kt	20		
Tweed	U-9bn	5/21/65	Shaft	Weapons Related	Less than 20 kt	20		
Organdy	U-9bo	6/11/65	Shaft	Weapons Related	Less than 20 kt	20		
Petrel	U-3dy	6/11/65	Shaft	Weapons Related	1.3 kt	1.3		
Tiny Tot	U-15e	6/17/65	Tunnel	Weapons Effects	Less than 20 kt	20	Accidental release of radioactivity detected onsite only	
Izzer	U-9bp	7/16/65	Shaft	Weapons Related	Less than 20 kt	20		
Pongee	U-2ah	7/22/65	Shaft	Weapons Related	Less than 20 kt	20	Accidental release of radioactivity detected onsite only	
Bronze	U-7f	7/23/65	Shaft	Weapons Related	20 to 200 kt	200		
Mauve	U-3dp	8/6/65	Shaft	Weapons Related	Less than 20 kt	20		
Ticking	U-9bj	8/21/65	Shaft	Weapons Related	Less than 20 kt	20		
Centaur	U-2ak	8/27/65	Shaft	Weapons Related	Less than 20 kt	20	Accidental release of radioactivity detected onsite only	
Moa	U-3ed	9/1/65	Shaft	Weapons Related	Less than 20 kt	20	Sim, sep; Accidental release of radioactivity detected onsite only	
Screamer	U-3dg	9/1/65	Shaft	Weapons Effects	Less than 20 kt	20	Sim, sep; Accidental release of radioactivity detected onsite only	
Charcoal	U-7g	9/10/65	Shaft	Joint US-UK	20 to 200 kt	200		
Elkhart	U-9bs	9/17/65	Shaft	Weapons Related	Less than 20 kt	20		
Sepia	U-3en	11/12/65	Shaft	Weapons Related	Less than 20 kt	20		
Kermet	U-2c	11/23/65	Shaft	Weapons Related	Less than 20 kt	20	Accidental release of radioactivity detected onsite only	
Corduroy	U-10k	12/3/65	Shaft	Weapons Related	20 to 200 kt	200		
Emerson	U-2aL	12/16/65	Shaft	Weapons Related	Less than 20 kt	20	Accidental release of radioactivity detected onsite only	
Buff	U-3dh	12/16/65	Shaft	Weapons Related	20 to 200 kt	200		
Maxwell	U-9br	1/13/66	Shaft	Weapons Related	Less than 20 kt	20		
Lampblack	U-7i	1/18/66	Shaft	Weapons Related	20 to 200 kt	200		
Sienna	U-3cj	1/18/66	Shaft	Weapons Related	Less than 20 kt	20		
Dovekie	U-3cd	1/21/66	Shaft	Weapons Related	Less than 20 kt	20		
Reo	U-10m	1/22/66	Shaft	Weapons Related	Less than 20 kt	20	Accidental release of radioactivity detected onsite only	
Plaid II	U-2r	2/3/66	Shaft	Weapons Related	Less than 20 kt	20	Accidental release of radioactivity detected onsite only	
Cinnamon	U-3dm	3/7/66	Shaft	Safety Experiment	Less than 20 kt	20	Sim, sep; Accidental release of radioactivity detected onsite only	
Finfoot	U-3du	3/7/66	Shaft	Weapons Related	Less than 20 kt	20	Sim, sep; Accidental release of radioactivity detected onsite only	
Clymer	U-9ce	3/12/66	Shaft	Weapons Related	Less than 20 kt	20		
Purple	U-3ds	3/18/66	Shaft	Weapons Related	Less than 20 kt	20		

Detonation Name[a]	Hole Name[a]	Detonation Date[a]	Emplacement Type[a]	Purpose[a]	Announced Yield[a] (kt)	Max Yield (kt)	Comment[a,b]	Known radionuclide migration[e]
Templar	U-9bt	3/24/66	Shaft	Plowshare	370 tons	0.37		
Lime	U-7j	4/1/66	Shaft	Weapons Related	Less than 20 kt	20		
Stutz	U-2ca	4/6/66	Shaft	Weapons Related	Less than 20 kt	20		
Tomato	U-3ek	4/7/66	Shaft	Weapons Related	Less than 20 kt	20		
Fenton	U-2m #1	4/23/66	Shaft	Weapons Related	1.4 kt	1.4	Accidental release of radioactivity detected offsite by aircraft only	
Ochre	U-3ec	4/29/66	Shaft	Safety Experiment	Less than 20 kt	20		
Traveler	U-2cd	5/4/66	Shaft	Weapons Related	Less than 20 kt	20		
Cyclamen	U-3cx	5/5/66	Shaft	Weapons Related	12 kt	12		
Tapestry	U-2an	5/12/66	Shaft	Weapons Related	Less than 20 kt	20	Accidental release of radioactivity detected onsite only	
Piranha	U-7e	5/13/66	Shaft	Weapons Related	20 to 200 kt	200		
Dumont	U-2t	5/19/66	Shaft	Weapons Related	20 to 200 kt	200		
Discus Thrower	U-8a	5/27/66	Shaft	Weapons Effects	22 kt	22		
Pile Driver	U-15.01	6/2/66	Tunnel	Weapons Effects	62 kt	62	Accidental release of radioactivity detected onsite only	
Tan	U-7k	6/3/66	Shaft	Weapons Related	20 to 200 kt	200		
Puce	U-3bs	6/10/66	Shaft	Weapons Related	Less than 20 kt	20		
Kankakee	U-10p	6/15/66	Shaft	Weapons Related	20 to 200 kt	200		
Vulcan	U-2bd	6/25/66	Shaft	Plowshare	25 kt	25		
Saxon	U-2cc	7/28/66	Shaft	Plowshare	1.2 kt	1.2		
Rovena	U-10s	8/10/66	Shaft	Weapons Related	Less than 20 kt	20		
Tangerine	U-3eb	8/12/66	Shaft	Safety Experiment	Less than 20 kt	20		
Daiquiri	U-7o	9/23/66	Shaft	Weapons Related	Less than 20 kt	20		
Newark	U-10u	9/29/66	Shaft	Weapons Related	Less than 20 kt	20		
Khaki	U-3et	10/15/66	Shaft	Weapons Related	Less than 20 kt	20		
Simms	U-10w	11/5/66	Shaft	Plowshare	2.3 kt	2.3		
Ajax	U-9aL	11/11/66	Shaft	Weapons Related	Less than 20 kt	20	Accidental release of radioactivity detected onsite only	
Cerise	U-3eu	11/18/66	Shaft	Weapons Related	Less than 20 kt	20	Accidental release of radioactivity detected onsite only	
Vigil	U-10ad	11/22/66	Shaft	Safety Experiment	Less than 20 kt	20	Accidental release of radioactivity detected onsite only	
Sidecar	U-3ez	12/13/66	Shaft	Weapons Related	Less than 20 kt	20	Accidental release of radioactivity detected onsite only	
Rivet I	U-10aa	1/18/67	Shaft	Weapons Related	Less than 20 kt	20		
Nash	U-2ce	1/19/67	Shaft	Weapons Related	39 kt	39	Accidental release of radioactivity detected offsite	Prompt injection to UE-2ce
Bourbon	U-7n	1/20/67	Shaft	Weapons Related	20 to 200 kt	200		Tritium in groundwater to UE-7nS
Rivet II	U-10z	1/26/67	Shaft	Weapons Related	Less than 20 kt	20	Accidental release of radioactivity detected onsite only	
Ward	U-10x	2/8/67	Shaft	Weapons Related	Less than 20 kt	20		
Agile	U-2v	2/23/67	Shaft	Weapons Related	20 to 200 kt	200		Tritium in groundwater to UE-2ar
Persimmon	U-3dn	2/23/67	Shaft	Weapons Related	Less than 20 kt	20		
Rivet III	U-10y	3/2/67	Shaft	Weapons Related	Less than 20 kt	20		
Mushroom	U-3ef	3/3/67	Shaft	Weapons Related	Less than 20 kt	20	Accidental release of radioactivity detected onsite only	
Fizz	U-3fr	3/10/67	Shaft	Safety Experiment	Less than 20 kt	20		
Oakland	U-2bi	4/4/67	Shaft	Weapons Related	Less than 20 kt	20		
Heilman	U-2cg	4/6/67	Shaft	Weapons Related	Less than 20 kt	20	Accidental release of radioactivity detected onsite only	

Detonation Name[a]	Hole Name[a]	Detonation Date[a]	Emplacement Type[a]	Purpose[a]	Announced Yield[a] (kt)	Max Yield (kt)	Comment[a,b]	Known radionuclide migration[e]
Fawn	U-3eo	4/7/67	Shaft	Weapons Related	Less than 20 kt	20		
Chocolate	U-3es	4/21/67	Shaft	Weapons Related	Less than 20 kt	20		
Effendi	U-2ap	4/27/67	Shaft	Weapons Related	Less than 20 kt	20		
Mickey	U-7m	5/10/67	Shaft	Weapons Related	20 to 200 kt	200		
Commodore	U-2am	5/20/67	Shaft	Weapons Related	250 kt	250		Tritium in groundwater to Stanyan site (U-2aw, UE-2aw)
Absinthe	U-3ep	5/26/67	Shaft	Safety Experiment	Less than 20 kt	20		
Switch	U-9bv	6/22/67	Shaft	Plowshare	3.1 kt	3.1		
Umber	U-3em	6/29/67	Shaft	Weapons Effects	10 kt	10	Accidental release of radioactivity detected offsite	
Vito	U-10ab	7/14/67	Shaft	Safety Experiment	Less than 20 kt	20		
Stanley	U-10q	7/27/67	Shaft	Weapons Related	20 to 200 kt	200		
Gibson	U-3ew	8/4/67	Shaft	Weapons Related	Less than 20 kt	20		
Washer	U-10r	8/10/67	Shaft	Weapons Related	Less than 20 kt	20		
Bordeaux	U-3dr	8/18/67	Shaft	Weapons Related	Less than 20 kt	20		
Lexington	U-2bm	8/24/67	Shaft	Weapons Related	Less than 20 kt	20		
Yard	U-10af	9/7/67	Shaft	Weapons Related	20 to 200 kt	200		
Gilroy	U-3ex	9/15/67	Shaft	Weapons Related	Less than 20 kt	20		
Marvel	U-10dS #1	9/21/67	Shaft	Plowshare	2.2 kt	2.2	Accidental release of radioactivity detected onsite only	
Zaza	U-4c	9/27/67	Shaft	Weapons Related	20 to 200 kt	200		
Lanpher	U-2x	10/18/67	Shaft	Weapons Related	20 to 200 kt	200		
Cognac	U-3fm	10/25/67	Shaft	Weapons Related	Less than 20 kt	20	Accidental release of radioactivity detected onsite only	
Sazerac	U-3fa	10/25/67	Shaft	Weapons Related	Less than 20 kt	20		
Worth	U-10ag	10/25/67	Shaft	Weapons Related	Less than 20 kt	20		
Cobbler	U-7u	11/8/67	Shaft	Weapons Related	Less than 20 kt	20		
Polka	U-10ai	12/6/67	Shaft	Weapons Related	Less than 20 kt	20		
Stilt	U-3fh	12/15/67	Shaft	Weapons Related	Less than 20 kt	20		
Hupmobile	U-2y	1/18/68	Shaft	Weapons Effects	7.4 kt	7.4	Accidental release of radioactivity detected offsite	
Staccato	U-10ah	1/19/68	Shaft	Weapons Related	20 to 200 kt	200		
Brush	U-3eq	1/24/68	Shaft	Weapons Related	Less than 20 kt	20	Accidental release of radioactivity detected onsite only	
Mallet	U-3fv	1/31/68	Shaft	Weapons Related	Less than 20 kt	20		
Knox	U-2at	2/21/68	Shaft	Weapons Related	20 to 200 kt	200		
Torch	U-3fj	2/21/68	Shaft	Weapons Related	Less than 20 kt	20		
Russet	U-6a	3/5/68	Shaft	Weapons Related	Less than 20 kt	20	Accidental release of radioactivity detected onsite only	
Pommard	U-3ee	3/14/68	Shaft	Weapons Related	1.5 kt	1.5		
Bevel	U-3fu	4/4/68	Shaft	Weapons Related	Less than 20 kt	20		
Noor	U-2be	4/10/68	Shaft	Weapons Related	20 to 200 kt	200	Simultaneous, separate holes	
Throw	U-2bg	4/10/68	Shaft	Weapons Related	Less than 20 kt	20	Simultaneous, separate holes	
Shuffle	U-10t	4/18/68	Shaft	Weapons Related	20 to 200 kt	200		
Hatchet	U-3fz	5/3/68	Shaft	Weapons Related	Less than 20 kt	20		
Crock	U-10ak	5/8/68	Shaft	Weapons Related	Less than 20 kt	20		
Clarksmobile	U-2as	5/17/68	Shaft	Weapons Related	20 to 200 kt	200		

Detonation Name[a]	Hole Name[a]	Detonation Date[a]	Emplacement Type[a]	Purpose[a]	Announced Yield[a] (kt)	Max Yield (kt)	Comment[a,b]	Known radionuclide migration[e]
Adze	U-3fw	5/28/68	Shaft	Weapons Related	Less than 20 kt	20	Accidental release of radioactivity detected onsite only	
Wembley	U-3ey	6/5/68	Shaft	Weapons Related	Less than 20 kt	20		
Tub-A	U-10aj C	6/6/68	Shaft	Weapons Related	Less than 20 kt	20	Simultaneous, separate holes	
Tub-B	U-10aj B	6/6/68	Shaft	Weapons Related	Less than 20 kt	20	Simultaneous, separate holes	
Tub-C	U-10aj F	6/6/68	Shaft	Weapons Related	Less than 20 kt	20	Simultaneous, separate holes	
Tub-D	U-10aj D	6/6/68	Shaft	Weapons Related	Less than 20 kt	20	Simultaneous, separate holes	
Tub-F	U-10aj A	6/6/68	Shaft	Weapons Related	Less than 20 kt	20	Simultaneous, separate holes	
Funnel	U-3ga	6/25/68	Shaft	Weapons Related	Less than 20 kt	20	Accidental release of radioactivity detected onsite only	
Sevilla	U-3fk	6/25/68	Shaft	Weapons Related	Less than 20 kt	20	Accidental release of radioactivity detected onsite only	
Spud	U-3fy	7/17/68	Shaft	Weapons Related	Less than 20 kt	20		
Tanya	U-2dt	7/30/68	Shaft	Weapons Related	20 to 200 kt	200		
Imp	U-2bj	8/9/68	Shaft	Weapons Related	Less than 20 kt	20	Accidental release of radioactivity detected onsite only	
Rack	U-9ap	8/15/68	Shaft	Weapons Related	Less than 20 kt	20		
Noggin	U-9bx	9/6/68	Shaft	Weapons Related	20 to 200 kt	200		
Knife A	U-3fb	9/12/68	Shaft	Weapons Related	Less than 20 kt	20		
Stoddard	U-2cm-S	9/17/68	Shaft	Plowshare	31 kt	31		
Knife C	U-3er	10/3/68	Shaft	Weapons Related	Less than 20 kt	20		
Welder	U-3fs	10/3/68	Shaft	Safety Experiment	Less than 20 kt	20		
Vat	U-9cf	10/10/68	Shaft	Weapons Related	Less than 20 kt	20		
Hula	U-9bu	10/29/68	Shaft	Weapons Related	Less than 20 kt	20	Accidental release of radioactivity detected onsite only	
Bit-A	U-3gt	10/31/68	Shaft	Safety Experiment	Less than 20 kt	20	Simultaneous, same hole	
Bit-B	U-3gt	10/31/68	Shaft	Safety Experiment	Less than 20 kt	20	Simultaneous, same hole	
File	U-3gb	10/31/68	Shaft	Weapons Related	Less than 20 kt	20		
Crew-2nd	U-2db	11/4/68	Shaft	Weapons Related	Less than 20 kt	20	Simultaneous, same hole	
Crew-3rd	U-2db	11/4/68	Shaft	Weapons Related	Less than 20 kt	20	Simultaneous, same hole	
Crew	U-2db	11/4/68	Shaft	Weapons Related	20 to 200 kt	200		
Auger	U-3fx	11/15/68	Shaft	Weapons Related	Less than 20 kt	20		
Knife B	U-3dz	11/15/68	Shaft	Weapons Related	Less than 20 kt	20		
Tinderbox	U-9az	11/22/68	Shaft	Weapons Related	Less than 20 kt	20		
Scissors	U-3gh	12/12/68	Shaft	Weapons Related	Less than 20 kt	20	Accidental release of radioactivity detected onsite only	
Tyg-A	U-2dc #4	12/12/68	Shaft	Weapons Related	Less than 20 kt	20	Sim, sep; Accidental release of radioactivity detected onsite only	
Tyg-B	U-2dc #5	12/12/68	Shaft	Weapons Related	Less than 20 kt	20	Sim, sep; Accidental release of radioactivity detected onsite only	
Tyg-C	U-2dc #3	12/12/68	Shaft	Weapons Related	Less than 20 kt	20	Sim, sep; Accidental release of radioactivity detected onsite only	
Tyg-D	U-2dc #2	12/12/68	Shaft	Weapons Related	Less than 20 kt	20	Sim, sep; Accidental release of radioactivity detected onsite only	
Tyg-E	U-2dc #1	12/12/68	Shaft	Weapons Related	Less than 20 kt	20	Sim, sep; Accidental release of radioactivity detected onsite only	
Tyg-F	U-2dc #6	12/12/68	Shaft	Weapons Related	Less than 20 kt	20	Sim, sep; Accidental release of radioactivity detected onsite only	
Bay Leaf	U-3gq	12/12/68	Shaft	Safety Experiment	Less than 20 kt	20		
Packard	U-2u	1/15/69	Shaft	Weapons Effects	10 kt	10	Accidental release of radioactivity detected onsite only	
Shave	U-3gk	1/22/69	Shaft	Weapons Related	Less than 20 kt	20		
Biggin	U-9bz	1/30/69	Shaft	Weapons Related	Less than 20 kt	20		

Detonation Name[a]	Hole Name[a]	Detonation Date[a]	Emplacement Type[a]	Purpose[a]	Announced Yield[a] (kt)	Max Yield (kt)	Comment[a,b]	Known radionuclide migration[e]
Vise	U-3ej	1/30/69	Shaft	Weapons Related	20 to 200 kt	200		
Nipper	U-3gL	2/4/69	Shaft	Weapons Related	Less than 20 kt	20		
Winch	U-3gf	2/4/69	Shaft	Weapons Related	Less than 20 kt	20		
Chatty	U-2bn	3/18/69	Shaft	Weapons Related	Less than 20 kt	20		
Valise	U-9by	3/18/69	Shaft	Safety Experiment	Less than 20 kt	20		
Barsac	U-3gc	3/20/69	Shaft	Weapons Related	Less than 20 kt	20	Accidental release of radioactivity detected onsite only	
Coffer	U-2de	3/21/69	Shaft	Weapons Related	Less than 100 kt	100		
Gourd-Amber	U-2bf	4/24/69	Shaft	Weapons Related	Less than 20 kt	20	Simultaneous, separate holes	
Gourd-Brown	U-2bL	4/24/69	Shaft	Weapons Related	Less than 20 kt	20	Simultaneous, separate holes	
Blenton	U-7p	4/30/69	Shaft	Weapons Related	20 to 200 kt	200	Accidental release of radioactivity detected onsite only	
Thistle	U-7t	4/30/69	Shaft	Weapons Related	20 to 200 kt	200		
Aliment	U-3gj	5/15/69	Shaft	Weapons Related	Less than 20 kt	20		
Ipecac-A	U-3hk-a	5/27/69	Shaft	Safety Experiment	Less than 20 kt	20	Sim, sep; Accidental release of radioactivity detected onsite only (trace)	
Ipecac-B	U-3hk-b	5/27/69	Shaft	Safety Experiment	Less than 20 kt	20	Sim, sep; Accidental release of radioactivity detected onsite only (trace)	
Torrido	U-7w	5/27/69	Shaft	Weapons Related	20 to 200 kt	200		
Tapper	U-3go	6/12/69	Shaft	Weapons Related	Less than 20 kt	20	Accidental release of radioactivity detected onsite only	
Bowl-1	U-2bo #1	6/26/69	Shaft	Weapons Related	Less than 20 kt	20	Simultaneous, separate holes	
Bowl-2	U-2bo #2	6/26/69	Shaft	Weapons Related	Less than 20 kt	20	Simultaneous, separate holes	
Hutch	U-2df	7/16/69	Shaft	Weapons Related	20 to 200 kt	200		
Ildrim	U-2au	7/16/69	Shaft	Weapons Related	20 to 200 kt	200		
Spider-A	U-2bp #1	8/14/69	Shaft	Weapons Related	Less than 20 kt	20	Simultaneous, separate holes	
Spider-B	U-2bp #2	8/14/69	Shaft	Weapons Related	Less than 20 kt	20	Simultaneous, separate holes	
Pliers	U-3gn	8/27/69	Shaft	Weapons Related	Less than 20 kt	20	Accidental release of radioactivity detected onsite only	
Horehound	U-3gm	8/27/69	Shaft	Weapons Related	Less than 20 kt	20		
Kyack-A	U-2bq #1	9/20/69	Shaft	Weapons Related	Less than 20 kt	20	Sim, sep; Accidental release of radioactivity detected onsite only	
Kyack-B	U-2bq #2	9/20/69	Shaft	Weapons Related	Less than 20 kt	20	Sim, sep; Accidental release of radioactivity detected onsite only	
Seaweed-C	U-3hk-e	10/1/69	Shaft	Safety Experiment	Less than 20 kt	20	Sim, sep; Accidental release of radioactivity detected onsite only	
Seaweed-D	U-3hk-f	10/1/69	Shaft	Safety Experiment	Less than 20 kt	20	Sim, sep; Accidental release of radioactivity detected onsite only	
Seaweed-E	U-3hk-c	10/1/69	Shaft	Safety Experiment	Less than 20 kt	20	Sim, sep; Accidental release of radioactivity detected onsite only	
Seaweed B	U-3hk-d	10/16/69	Shaft	Safety Experiment	Less than 20 kt	20	Accidental release of radioactivity detected onsite only	
Pod-A	U-2ck	10/29/69	Shaft	Weapons Related	16.7 kt (Total)	16.7	Sim, sep; Accidental release of radioactivity detected offsite only	
Pod-B	U-2ch	10/29/69	Shaft	Weapons Related			Sim, sep; Accidental release of radioactivity detected offsite only	
Pod-C	U-2ci	10/29/69	Shaft	Weapons Related			Sim, sep; Accidental release of radioactivity detected offsite only	
Pod-D	U-2cj	10/29/69	Shaft	Weapons Related			Sim, sep; Accidental release of radioactivity detected offsite only	
Calabash	U-2av	10/29/69	Shaft	Weapons Related	110 kt	110		
Cruet	U-2cn	10/29/69	Shaft	Weapons Related	11 kt	11		
Scuttle	U-2bh	11/13/69	Shaft	Weapons Related	1.7 kt	1.7	Accidental release of radioactivity detected offsite by aircraft only	
Piccalilli	U-3fc	11/21/69	Shaft	Weapons Related	20 to 200 kt	200		
Planer	U-3eL	11/21/69	Shaft	Weapons Related	Less than 20 kt	20		
Tun-A	U-10am #1	12/10/69	Shaft	Weapons Related	Less than 20 kt	20	Sim, sep; Accidental release of radioactivity detected onsite only	

Detonation Name[a]	Hole Name[a]	Detonation Date[a]	Emplacement Type[a]	Purpose[a]	Announced Yield[a] (kt)	Max Yield (kt)	Comment[a,b]	Known radionuclide migration[e]
Tun-B	U-10am #2	12/10/69	Shaft	Weapons Related	Less than 20 kt	20	Sim, sep; Accidental release of radioactivity detected onsite only	
Tun-C	U-10am #3	12/10/69	Shaft	Weapons Related	Less than 20 kt	20	Sim, sep; Accidental release of radioactivity detected onsite only	
Tun-D	U-10am #4	12/10/69	Shaft	Weapons Related	Less than 20 kt	20	Sim, sep; Accidental release of radioactivity detected onsite only	
Culantro-A	U-3hi-a	12/10/69	Shaft	Weapons Related	Less than 20 kt	20	Simultaneous, separate holes	
Culantro-B	U-3hi-b	12/10/69	Shaft	Weapons Related	Less than 20 kt	20	Simultaneous, separate holes	
Grape A	U-7s	12/17/69	Shaft	Weapons Related	20 to 200 kt	200		
Lovage	U-3fe	12/17/69	Shaft	Weapons Related	Less than 20 kt	20		
Terrine-White	U-9bi #1	12/18/69	Shaft	Weapons Related	20 to 200 kt	200	Simultaneous, separate holes	
Terrine-Yellow	U-9bi #2	12/18/69	Shaft	Weapons Related	20 to 200 kt	200	Simultaneous, separate holes	
Fob-Blue	U-9 ITS Y-27	1/23/70	Shaft	Weapons Related	Less than 20 kt	20	Simultaneous, separate holes	
Fob-Green	U-9 ITS V-27	1/23/70	Shaft	Weapons Related	Less than 20 kt	20	Simultaneous, separate holes	
Fob-Red	U-9 ITS V-24	1/23/70	Shaft	Weapons Related	Less than 20 kt	20	Simultaneous, separate holes	
Ajo	U-3gd	1/30/70	Shaft	Weapons Related	Less than 20 kt	20		
Belen	U-3br	2/4/70	Shaft	Weapons Related	20 to 200 kt	200		
Grape B	U-7v	2/4/70	Shaft	Weapons Related	20 to 200 kt	200		
Labis	U-10an	2/5/70	Shaft	Weapons Related	25 kt	25		
Cumarin	U-3gz	2/25/70	Shaft	Weapons Related	20 to 200 kt	200		
Yannigan-Blue	U-2ay #3	2/26/70	Shaft	Weapons Related	20 to 200 kt	200	Simultaneous, separate holes	
Yannigan-Red	U-2ay #1	2/26/70	Shaft	Weapons Related	20 to 200 kt	200	Simultaneous, separate holes	
Yannigan-White	U-2ay #2	2/26/70	Shaft	Weapons Related	20 to 200 kt	200	Simultaneous, separate holes	
Arabis-Blue	U-9 ITS Z-26	3/6/70	Shaft	Safety Experiment	Less than 20 kt	20	Simultaneous, separate holes	
Arabis-Green	U-9 ITS X-28	3/6/70	Shaft	Weapons Related	Less than 20 kt	20	Simultaneous, separate holes	
Arabis-Red	U-9 ITS V-26	3/6/70	Shaft	Weapons Related	Less than 20 kt	20	Simultaneous, separate holes	
Cyathus	U-8b	3/6/70	Shaft	Weapons Related	8.7 kt	8.7		
Jal	U-3hh	3/19/70	Shaft	Weapons Related	Less than 20 kt	20		
Shaper	U-7r	3/23/70	Shaft	Weapons Related	20 to 200 kt	200		
Snubber	U-3ev-2S	4/21/70	Shaft	Weapons Effects	12.7 kt	12.7	Accidental release of radioactivity detected offsite	
Can-Green	U-2dd #1	4/21/70	Shaft	Weapons Related	20 to 200 kt	200	Simultaneous, separate holes	
Can-Red	U-2dd #4	4/21/70	Shaft	Weapons Related	20 to 200 kt	200	Simultaneous, separate holes	
Hod-A (Green)	U-9 ITS X-23	5/1/70	Shaft	Weapons Related	Less than 20 kt	20	Sim, sep; Accidental release of radioactivity detected onsite only	
Hod-B (Red)	U-9 ITS X-20	5/1/70	Shaft	Weapons Related	Less than 20 kt	20	Sim, sep; Accidental release of radioactivity detected onsite only	
Beebalm	U-3fn	5/1/70	Shaft	Weapons Related	Less than 20 kt	20		
Hod-C (Blue)	U-9 ITS Z-25	5/1/70	Shaft	Safety Experiment	Less than 20 kt	20		
Cornice-Green	U-10ap #3	5/15/70	Shaft	Weapons Related	20 to 200 kt	200	Simultaneous, separate holes	
Cornice-Yellow	U-10ap #1	5/15/70	Shaft	Weapons Related	20 to 200 kt	200	Simultaneous, separate holes	
Manzanas	U-3gr	5/21/70	Shaft	Weapons Related	Less than 20 kt	20	Accidental release of radioactivity detected onsite only	
Morrones	U-3ei	5/21/70	Shaft	Weapons Related	20 to 200 kt	200		
Flask-Green	U-2az #1	5/26/70	Shaft	Plowshare	105 kt	105	Sim, sep; Accidental release of radioactivity detected onsite only	
Flask-Red	U-2az #3	5/26/70	Shaft	Plowshare	35 tons	0.035	Sim, sep; Accidental release of radioactivity detected onsite only	
Flask-Yellow	U-2az #2	5/26/70	Shaft	Plowshare	90 tons	0.09	Sim, sep; Accidental release of radioactivity detected onsite only	

Detonation Name[a]	Hole Name[a]	Detonation Date[a]	Emplacement Type[a]	Purpose[a]	Announced Yield[a] (kt)	Max Yield (kt)	Comment[a,b]	Known radionuclide migration[e]
Piton-C	U-9 ITS AA-25	5/28/70	Shaft	Weapons Related	Less than 20 kt	20	Accidental release of radioactivity detected onsite only	
Piton-A	U-9 ITS Y-30	5/28/70	Shaft	Weapons Related	Less than 20 kt	20	Sim, sep; Accidental release of radioactivity detected onsite only	
Piton-B	U-9 ITS X-27	5/28/70	Shaft	Weapons Related	Less than 20 kt	20	Sim, sep; Accidental release of radioactivity detected onsite only	
Arnica-Violet	U-2dd #3	6/26/70	Shaft	Weapons Related	Less than 20 kt	20	Simultaneous, separate holes	
Arnica-Yellow	U-2dd #2	6/26/70	Shaft	Weapons Related	Less than 20 kt	20	Simultaneous, separate holes	
Scree-Acajou	U-9 ITS X-24	10/13/70	Shaft	Weapons Related	Less than 20 kt	20	Sim, sep; Accidental release of radioactivity detected onsite only	
Scree-Alhambra	U-9 ITS Z-21	10/13/70	Shaft	Weapons Related	Less than 20 kt	20	Sim, sep; Accidental release of radioactivity detected onsite only	
Scree-Chamois	U-9 ITS Z-24	10/13/70	Shaft	Safety Experiment	Less than 20 kt	20	Sim, sep; Accidental release of radioactivity detected onsite only	
Tijeras	U-7y	10/14/70	Shaft	Weapons Related	20 to 200 kt	200		
Truchas-Chacon	U-3hn	10/28/70	Shaft	Safety Experiment	Less than 20 kt	20	Sim, sep; Accidental release of radioactivity detected onsite only	
Truchas-Chamisal	U-3ho	10/28/70	Shaft	Safety Experiment	Less than 20 kt	20	Sim, sep; Accidental release of radioactivity detected onsite only	
Truchas-Rodarte	U-3hm	10/28/70	Shaft	Weapons Related	Less than 20 kt	20	Sim, sep; Accidental release of radioactivity detected onsite only	
Abeytas	U-3gx	11/5/70	Shaft	Weapons Related	20 to 200 kt	200		
Penasco	U-3hL	11/19/70	Shaft	Weapons Related	Less than 20 kt	20		
Carrizozo	U-3hr	12/3/70	Shaft	Weapons Related	Less than 20 kt	20	Simultaneous, separate holes	
Corazon	U-3ha	12/3/70	Shaft	Weapons Related	Less than 20 kt	20	Simultaneous, separate holes	
Avens-Andorre	U-9 ITS T-28	12/16/70	Shaft	Weapons Related	Less than 20 kt	20	Sim, sep; Accidental release of radioactivity detected onsite only	Prompt injection to U-9 ITS U-29
Avens-Alkermes	U-9 ITS U-24	12/16/70	Shaft	Weapons Related	Less than 20 kt	20	Sim, sep; Accidental release of radioactivity detected onsite only	
Avens-Asamlte	U-9 ITS W-21	12/16/70	Shaft	Weapons Related	Less than 20 kt	20	Sim, sep; Accidental release of radioactivity detected onsite only	
Avens-Cream	U-9 ITS X-29	12/16/70	Shaft	Weapons Related	Less than 20 kt	20	Sim, sep; Accidental release of radioactivity detected onsite only	
Artesia	U-7x	12/16/70	Shaft	Weapons Related	20 to 200 kt	200		
Canjilon	U-3fq	12/16/70	Shaft	Weapons Related	Less than 20 kt	20		
Carpetbag	U-2dg	12/17/70	Shaft	Weapons Related	220 kt	220		
Baneberry	U-8d	12/18/70	Shaft	Weapons Related	10 kt	10	Accidental release of radioactivity detected offsite	
Embudo	U-3hd	6/16/71	Shaft	Weapons Related	Less than 20 kt	20		
Dexter	U-3hs	6/23/71	Shaft	Safety Experiment	Less than 20 kt	20		
Laguna	U-3fd	6/23/71	Shaft	Weapons Related	20 to 200 kt	200		
Harebell	U-2br	6/24/71	Shaft	Weapons Related	20 to 200 kt	200		
Miniata	U-2bu	7/8/71	Shaft	Plowshare	83 kt	83		
Bracken	U-10aq	7/9/71	Shaft	Weapons Related	Less than 20 kt	20		
Apodaca	U-3gs	7/21/71	Shaft	Weapons Related	Less than 20 kt	20		
Barranca	U-3he	8/4/71	Shaft	Weapons Related	Less than 20 kt	20		
Nama-Amarylis	U-9 ITS XY-31	8/5/71	Shaft	Weapons Related	Less than 20 kt	20	Simultaneous, separate holes	
Nama-Mephisto	U-9 ITS Z-27	8/5/71	Shaft	Weapons Related	Less than 20 kt	20	Simultaneous, separate holes	
Baltic	U-9 ITS S-25	8/6/71	Shaft	Weapons Related	Less than 20 kt	20		
Algodones	U-3jn	8/18/71	Shaft	Weapons Related	20 to 200 kt	200		
Frijoles-Deming	U-3jw	9/22/71	Shaft	Safety Experiment	Less than 20 kt	20	Simultaneous, separate holes	
Frijoles-Espuela	U-3ju	9/22/71	Shaft	Safety Experiment	Less than 20 kt	20	Simultaneous, separate holes	
Frijoles-Guaje	U-3hf	9/22/71	Shaft	Weapons Related	Less than 20 kt	20	Simultaneous, separate holes	
Frijoles-Petaca	U-3hz	9/22/71	Shaft	Weapons Related	Less than 20 kt	20	Simultaneous, separate holes	

Detonation Name[a]	Hole Name[a]	Detonation Date[a]	Emplacement Type[a]	Purpose[a]	Announced Yield[a] (kt)	Max Yield (kt)	Comment[a,b]	Known radionuclide migration[e]
Chantilly	U-2di	9/29/71	Shaft	Weapons Related	Less than 20 kt	20		
Pedernal	U-3hg	9/29/71	Shaft	Weapons Related	Less than 20 kt	20		
Cathay	U-9ch	10/8/71	Shaft	Weapons Related	Less than 20 kt	20		
Lagoon	U-10ar	10/14/71	Shaft	Weapons Related	Less than 20 kt	20		
Parnassia	U-2bc	11/30/71	Shaft	Weapons Related	Less than 20 kt	20		
Chaenactis	U-2dL	12/14/71	Shaft	Weapons Related	20 to 200 kt	200		
Hospah	U-3je	12/14/71	Shaft	Weapons Related	Less than 20 kt	20		
Yerba	U-1c	12/14/71	Shaft	Weapons Related	Less than 20 kt	20		
Mescalero	U-3gu	1/5/72	Shaft	Weapons Related	Less than 20 kt	20		
Cowles	U-3hx	2/3/72	Shaft	Weapons Related	Less than 20 kt	20		
Dianthus	U-10at	2/17/72	Shaft	Weapons Related	Less than 20 kt	20		
Sappho	U-2dh #2	3/23/72	Shaft	Weapons Related	Less than 20 kt	20		
Ocate	U-3jp	3/30/72	Shaft	Weapons Related	Less than 20 kt	20	Simultaneous, separate holes	
Onaja	U-3js	3/30/72	Shaft	Weapons Related	Less than 20 kt	20	Simultaneous, separate holes	
Jicarilla	U-3jm	4/19/72	Shaft	Weapons Related	Less than 20 kt	20		
Longchamps	U-2dm	4/19/72	Shaft	Weapons Related	Less than 20 kt	20		
Kara	U-2dh #3	5/11/72	Shaft	Weapons Related	Less than 20 kt	20		
Zinnia	U-2dk	5/17/72	Shaft	Weapons Related	Less than 20 kt	20		
Monero	U-3jq	5/19/72	Shaft	Weapons Related	Less than 20 kt	20		
Merida	U-2dn	6/7/72	Shaft	Weapons Related	Less than 20 kt	20		
Capitan	U-3jj	6/28/72	Shaft	Weapons Related	Less than 20 kt	20		
Haplopappus	U-9 ITS W-22	6/28/72	Shaft	Weapons Related	Less than 20 kt	20		
Tajique	U-7aa	6/28/72	Shaft	Weapons Related	Less than 20 kt	20		
Atarque	U-3ht	7/25/72	Shaft	Weapons Related	Less than 20 kt	20		
Cebolla	U-3jc	8/9/72	Shaft	Weapons Related	Less than 20 kt	20	Simultaneous, separate holes	
Cuchillo	U-3jt	8/9/72	Shaft	Weapons Related	Less than 20 kt	20	Simultaneous, separate holes	
Solano	U-3jx	8/9/72	Shaft	Safety Experiment	Less than 20 kt	20	Simultaneous, separate holes	
Oscuro	U-7z	9/21/72	Shaft	Weapons Related	20 to 200 kt	200		
Delphinium	U-2dp	9/26/72	Shaft	Weapons Related	15 kt	15		
Akbar	U-10ax	11/9/72	Shaft	Weapons Related	Less than 20 kt	20		
Arsenate	U-9ci	11/9/72	Shaft	Weapons Related	Less than 20 kt	20		
Canna-Limoges	U-9 ITS YZ-26	11/17/72	Shaft	Safety Experiment	Less than 20 kt	20	Simultaneous, same hole	
Canna-Umbrinus	U-9 ITS YZ-26	11/17/72	Shaft	Weapons Related	Less than 20 kt	20	Simultaneous, same hole	
Tuloso	U-3gi	12/12/72	Shaft	Weapons Related	Less than 20 kt	20		
Solanum	U-9 ITS W-24.5	12/14/72	Shaft	Weapons Related	Less than 20 kt	20		
Flax-Backup	U-2dj	12/21/72	Shaft	Weapons Effects	Less than 20 kt	20	Simultaneous, same hole	
Flax-Test	U-2dj	12/21/72	Shaft	Weapons Effects	20 to 200 kt	200	Simultaneous, same hole	
Flax-Source	U-2dj	12/21/72	Shaft	Weapons Related	Less than 20 kt	20		
Alumroot	U-9cj	2/14/73	Shaft	Weapons Related	Less than 20 kt	20		
Miera	U-7ad	3/8/73	Shaft	Weapons Related	20 to 200 kt	200		

Detonation Name[a]	Hole Name[a]	Detonation Date[a]	Emplacement Type[a]	Purpose[a]	Announced Yield[a] (kt)	Max Yield (kt)	Comment[a,b]	Known radionuclide migration[e]
Gazook	U-2do	3/23/73	Shaft	Weapons Related	Less than 20 kt	20		
Natoma	U-10aw	4/5/73	Shaft	Weapons Related	Less than 20 kt	20		
Angus	U-3jg	4/25/73	Shaft	Weapons Related	Less than 20 kt	20	Simultaneous, separate holes	
Velarde	U-3jk	4/25/73	Shaft	Weapons Related	Less than 20 kt	20	Simultaneous, separate holes	
Colmor	U-3hv	4/26/73	Shaft	Weapons Related	Less than 20 kt	20		
Starwort	U-2bs	4/26/73	Shaft	Weapons Related	90 kt	90		
Mesita	U-3jd	5/9/73	Shaft	Weapons Related	Less than 20 kt	20		
Cabresto	U-7h	5/24/73	Shaft	Weapons Related	Less than 20 kt	20		
Kashan	U-10av	5/24/73	Shaft	Weapons Related	Less than 20 kt	20		
Potrillo	U-7af	6/21/73	Shaft	Weapons Related	20 to 200 kt	200		
Portulaca	U-2bv	6/28/73	Shaft	Weapons Related	20 to 200 kt	200		
Silene	U-9ck	6/28/73	Shaft	Weapons Related	Less than 20 kt	20		
Polygonum	U-2by	10/2/73	Shaft	Weapons Related	Less than 20 kt	20		
Waller	U-2bz	10/2/73	Shaft	Weapons Related	Less than 20 kt	20		
Bernal	U-3jy	11/28/73	Shaft	Weapons Related	Less than 20 kt	20		
Pajara	U-3ji	12/12/73	Shaft	Weapons Related	Less than 20 kt	20		
Seafoam	U-2ea	12/13/73	Shaft	Weapons Related	Less than 20 kt	20		
Elida	U-3hy	12/19/73	Shaft	Weapons Related	Less than 20 kt	20		
Spar	U-3jr	12/19/73	Shaft	Safety Experiment	Less than 20 kt	20		
Pinedrops-Bayou	U-10as	1/10/74	Shaft	Weapons Related	Less than 20 kt	20	Simultaneous, same hole	
Pinedrops-Sloat	U-10as	1/10/74	Shaft	Weapons Related	Less than 20 kt	20	Simultaneous, same hole	
Pinedrops-Tawny	U-10as	1/10/74	Shaft	Weapons Related	Less than 20 kt	20	Simultaneous, same hole	
Latir	U-4d	2/27/74	Shaft	Weapons Related	20 to 200 kt	200		Prompt injection to UE-4g #2 (Iceberg site)
Hulsea	U-2bx	3/14/74	Shaft	Weapons Related	Less than 20 kt	20		
Sapello	U-3ge	4/12/74	Shaft	Weapons Related	Less than 20 kt	20		
Potrero	U-2eb	4/23/74	Shaft	Weapons Related	Less than 20 kt	20		
Plomo	U-3ff	5/1/74	Shaft	Weapons Related	Less than 20 kt	20		
Jib	U-3hb	5/8/74	Shaft	Weapons Related	Less than 20 kt	20		
Grove	U-2ds	5/22/74	Shaft	Weapons Related	Less than 20 kt	20		
Fallon	U-2dv	5/23/74	Shaft	Joint US-UK	20 to 200 kt	200		
Jara	U-3hp	6/6/74	Shaft	Weapons Related	Less than 20 kt	20		
Escabosa	U-7ac	7/10/74	Shaft	Weapons Related	20 to 200 kt	200		
Crestlake-Briar	U-2dw	7/18/74	Shaft	Weapons Related	Less than 20 kt	20	Simultaneous, same hole	
Crestlake-Tansan	U-2dw	7/18/74	Shaft	Weapons Related	Less than 20 kt	20	Simultaneous, same hole	
Puye	U-3jL	8/14/74	Shaft	Weapons Related	Less than 20 kt	20		
Portmanteau	U-2ax	8/30/74	Shaft	Weapons Related	20 to 200 kt	200		
Pratt	U-3hq	9/25/74	Shaft	Weapons Related	Less than 20 kt	20		
Stanyan	U-2aw	9/26/74	Shaft	Weapons Related	20 to 200 kt	200		Tritium in groundwater from Commodore (U-2am)
Trumbull	U-4aa	9/26/74	Shaft	Weapons Related	Less than 20 kt	20		
Estaca	U-3ja	10/17/74	Shaft	Weapons Related	Less than 20 kt	20		

Detonation Name[a]	Hole Name[a]	Detonation Date[a]	Emplacement Type[a]	Purpose[a]	Announced Yield[a] (kt)	Max Yield (kt)	Comment[a,b]	Known radionuclide migration[e]
Temescal	U-4ab	11/2/74	Shaft	Weapons Related	Less than 20 kt	20		
Puddle	U-3kg	11/26/74	Shaft	Safety Experiment	Less than 20 kt	20		
Keel	U-3hu	12/16/74	Shaft	Weapons Related	Less than 20 kt	20		
Portola	U-10bb	2/6/75	Shaft	Weapons Related	Less than 20 kt	20	Simultaneous, same hole	
Portola-Larkin	U-10bb	2/6/75	Shaft	Weapons Related	Less than 20 kt	20	Simultaneous, same hole	
Teleme	U-9cL	2/6/75	Shaft	Weapons Related	Less than 20 kt	20		
Bilge	U-3kc	2/19/75	Shaft	Weapons Related	Less than 20 kt	20		
Topgallant	U-4e	2/28/75	Shaft	Weapons Related	20 to 200 kt	200		
Cabrillo	U-2dr	3/7/75	Shaft	Weapons Related	20 to 200 kt	200		
Edam	U-2dy	4/24/75	Shaft	Weapons Related	20 to 200 kt	200		
Obar	U-7ag	4/30/75	Shaft	Weapons Related	20 to 200 kt	200		
Mizzen	U-7ah	6/3/75	Shaft	Weapons Related	20 to 200 kt	200		
Alviso	U-2du	6/11/75	Shaft	Safety Experiment	Less than 20 kt	20		
Futtock	U-3eh	6/18/75	Shaft	Safety Experiment	Less than 20 kt	20		
Marsh	U-3kb	9/6/75	Shaft	Weapons Related	Less than 20 kt	20		
Deck	U-3kd	11/18/75	Shaft	Weapons Related	Less than 20 kt	20		
Leyden	U-9cm	11/26/75	Shaft	Weapons Related	Less than 20 kt	20		
Chiberta	U-2ek	12/20/75	Shaft	Weapons Related	20 to 200 kt	200		
Esrom	U-7ak	2/4/76	Shaft	Weapons Related	20 to 200 kt	200		
Keelson	U-7ai	2/4/76	Shaft	Weapons Related	20 to 200 kt	200		
Shallows	U-3jf	2/26/76	Shaft	Weapons Related	Less than 20 kt	20		
Strait	U-4a	3/17/76	Shaft	Weapons Related	200 to 500 kt	500		
Rivoli	U-2eg	5/20/76	Shaft	Weapons Related	Less than 20 kt	20	Accidental release of radioactivity detected onsite only	
Billet	U-7an	7/27/76	Shaft	Weapons Related	20 to 150 kt	150		
Banon	U-2dz	8/26/76	Shaft	Joint US-UK	20 to 150 kt	150		
Gouda	U-2ef	10/6/76	Shaft	Weapons Related	Less than 20 kt	20		
Sprit	U-3hc	11/10/76	Shaft	Weapons Related	Less than 20 kt	20		
Chevre	U-10ay	11/23/76	Shaft	Weapons Related	Less than 20 kt	20		
Redmud	U-7ab	12/8/76	Shaft	Weapons Related	Less than 20 kt	20		
Asiago	U-2ar	12/21/76	Shaft	Weapons Related	Less than 20 kt	20		
Sutter	U-2bw	12/21/76	Shaft	Weapons Related	Less than 20 kt	20		
Rudder	U-7ajS	12/28/76	Shaft	Weapons Related	20 to 150 kt	150		
Cove	U-3ki	2/16/77	Shaft	Weapons Related	Less than 20 kt	20	Simultaneous, separate holes	
Oarlock	U-3km	2/16/77	Shaft	Weapons Related	Less than 20 kt	20	Simultaneous, separate holes	
Dofino	U-10ba	3/8/77	Shaft	Weapons Related	Less than 20 kt	20	Simultaneous, same hole	
Dofino-Lawton	U-10ba	3/8/77	Shaft	Weapons Related	Less than 20 kt	20	Simultaneous, same hole	
Marsilly	U-2eL	4/5/77	Shaft	Weapons Related	20 to 150 kt	150		
Bulkhead	U-7am	4/27/77	Shaft	Weapons Related	20 to 150 kt	150		
Crewline	U-7ap	5/25/77	Shaft	Weapons Related	20 to 150 kt	150		
Forefoot	U-3kf	6/2/77	Shaft	Weapons Related	Less than 20 kt	20		

Detonation Name[a]	Hole Name[a]	Detonation Date[a]	Emplacement Type[a]	Purpose[a]	Announced Yield[a] (kt)	Max Yield (kt)	Comment[a,b]	Known radionuclide migration[e]
Carnelian	U-4af	7/28/77	Shaft	Weapons Related	Less than 20 kt	20		
Strake	U-7ae	8/4/77	Shaft	Weapons Related	20 to 150 kt	150		
Gruyere	U-9cg	8/16/77	Shaft	Weapons Related	Less than 20 kt	20	Simultaneous, same hole	
Gruyere-Gradino	U-9cg	8/16/77	Shaft	Weapons Related	Less than 20 kt	20	Simultaneous, same hole	
Flotost	U-2ao	8/16/77	Shaft	Weapons Related	Less than 20 kt	20		
Scantling	U-4h	8/19/77	Shaft	Weapons Related	20 to 150 kt	150		
Scupper	U-3hj	8/19/77	Shaft	Weapons Related	Less than 20 kt	20		
Ebbtide	U-3kt	9/15/77	Shaft	Weapons Related	Less than 20 kt	20		
Coulommiers	U-2ei	9/27/77	Shaft	Weapons Related	20 to 150 kt	150		
Bobstay	U-3jb	10/26/77	Shaft	Weapons Related	Less than 20 kt	20		
Sandreef	U-7aq	11/9/77	Shaft	Weapons Related	20 to 150 kt	150		Prompt injection to U-3kz (Aleman)
Seamount	U-3kp	11/17/77	Shaft	Weapons Related	Less than 20 kt	20		
Farallones	U-2fa	12/14/77	Shaft	Weapons Related	20 to 150 kt	150		
Rib	U-3jv	12/14/77	Shaft	Weapons Related	Less than 20 kt	20		
Campos	U-9cp	2/13/78	Shaft	Weapons Related	Less than 20 kt	20		
Reblochon	U-2en	2/23/78	Shaft	Weapons Related	20 to 150 kt	150		
Karab	U-4ah	3/16/78	Shaft	Weapons Related	Less than 20 kt	20		
Iceberg	U-4g	3/23/78	Shaft	Weapons Related	20 to 150 kt	150		
Topmast	U-7ay	3/23/78	Shaft	Weapons Related	Less than 20 kt	20		
Asco	U-10bc	4/25/78	Shaft	Safety Experiment	Less than 20 kt	20		
Transom	U-4f	5/10/78	Shaft	Weapons Related	Zero	0	No nuclear yield; device destroyed by Hearts detonation	
Jackpots	U-3kj	6/1/78	Shaft	Weapons Related	Less than 20 kt	20		
Satz	U-2dq	7/7/78	Shaft	Weapons Related	Less than 20 kt	20		
Lowball	U-7av	7/12/78	Shaft	Weapons Related	20 to 150 kt	150		
Cremino	U-8e	9/27/78	Shaft	Weapons Related	Less than 20 kt	20	Simultaneous, same hole	
Cremino-Caerphilly	U-8e	9/27/78	Shaft	Weapons Related	Less than 20 kt	20	Simultaneous, same hole	
Draughts	U-7aL	9/27/78	Shaft	Weapons Related	20 to 150 kt	150		
Rummy	U-7au	9/27/78	Shaft	Weapons Related	20 to 150 kt	150		
Quargel	U-2fb	11/18/78	Shaft	Joint US-UK	20 to 150 kt	150		
Concentration	U-3kn	12/1/78	Shaft	Weapons Related	Less than 20 kt	20		
Baccarat	U-7ax	1/24/79	Shaft	Weapons Related	Less than 20 kt	20		
Quinella	U-4L	2/8/79	Shaft	Weapons Related	20 to 150 kt	150		
Kloster	U-2eo	2/15/79	Shaft	Weapons Related	20 to 150 kt	150		
Memory	U-3kq	3/14/79	Shaft	Weapons Related	Less than 20 kt	20		
Freezeout	U-3kw	5/11/79	Shaft	Weapons Related	Less than 20 kt	20		
Chess	U-7at	6/20/79	Shaft	Weapons Related	Less than 20 kt	20		
Fajy	U-2fc	6/28/79	Shaft	Weapons Related	20 to 150 kt	150		
Burzet	U-4ai	8/3/79	Shaft	Weapons Related	20 to 150 kt	150		
Offshore	U-3ks	8/8/79	Shaft	Weapons Related	20 to 150 kt	150		
Nessel	U-2ep	8/29/79	Shaft	Joint US-UK	20 to 150 kt	150		

Detonation Name[a]	Hole Name[a]	Detonation Date[a]	Emplacement Type[a]	Purpose[a]	Announced Yield[a] (kt)	Max Yield (kt)	Comment[a,b]	Known radionuclide migration[e]
Hearts	U-4n	9/6/79	Shaft	Weapons Related	140 kt	140	Detonation destroyed undetonated Transom device	
Pera	U-10bd	9/8/79	Shaft	Weapons Related	Less than 20 kt	20		
Backgammon	U-3jh	11/29/79	Shaft	Weapons Related	Less than 20 kt	20		
Azul	U-2em	12/14/79	Shaft	Weapons Related	Less than 20 kt	20	Detonation destroyed Peninsula device	
Tarko	U-2fd	2/28/80	Shaft	Weapons Related	Less than 20 kt	20		
Norbo	U-8c	3/8/80	Shaft	Weapons Related	Less than 20 kt	20	Accidental release of radioactivity detected onsite only	
Liptauer	U-2eh	4/3/80	Shaft	Weapons Related	20 to 150 kt	150		
Pyramid	U-7be	4/16/80	Shaft	Weapons Related	20 to 150 kt	150		
Canfield	U-3kx	5/2/80	Shaft	Weapons Related	Less than 20 kt	20		
Flora	U-3Lg	5/22/80	Shaft	Weapons Related	Less than 20 kt	20		
Huron King	U-3ky	6/24/80	Shaft	Weapons Effects	Less than 20 kt	20		
Verdello	U-3ku	7/31/80	Shaft	Weapons Related	Less than 20 kt	20		
Riola	U-2eq	9/25/80	Shaft	Weapons Related	1.07 kt	1.07	Accidental release of radioactivity detected offsite	
Bonarda	U-3gv	9/25/80	Shaft	Weapons Related	20 to 150 kt	150		
Dutchess	U-7bm	10/24/80	Shaft	Joint US-UK	Less than 20 kt	20		
Dauphin	U-9cq	11/14/80	Shaft	Weapons Related	Less than 20 kt	20		
Baseball	U-7ba	1/15/81	Shaft	Weapons Related	20 to 150 kt	150		
Clairette	U-3kr	2/5/81	Shaft	Weapons Related	Less than 20 kt	20		
Seco	U-8L	2/25/81	Shaft	Weapons Related	Less than 20 kt	20		
Vide	U-8k	4/30/81	Shaft	Weapons Related	Less than 20 kt	20		
Aligote	U-7bg	5/29/81	Shaft	Weapons Related	Less than 20 kt	20		
Niza	U-9cr	7/10/81	Shaft	Weapons Related	Less than 20 kt	20		
Pineau	U-7ao	7/16/81	Shaft	Weapons Related	Less than 20 kt	20		
Havarti	U-10bg	8/5/81	Shaft	Weapons Related	Less than 20 kt	20		
Islay	U-2er	8/27/81	Shaft	Weapons Related	Less than 20 kt	20		
Trebbiano	U-3Lj	9/4/81	Shaft	Weapons Related	Less than 20 kt	20		
Cernada	U-3kk	9/24/81	Shaft	Weapons Related	Less than 20 kt	20		
Paliza	U-7bd	10/1/81	Shaft	Weapons Related	20 to 150 kt	150		
Tilci	U-4ak	11/11/81	Shaft	Weapons Related	20 to 150 kt	150		
Rousanne	U-4p	11/12/81	Shaft	Joint US-UK	20 to 150 kt	150		
Akavi	U-2es	12/3/81	Shaft	Weapons Related	20 to 150 kt	150		
Caboc	U-2cp	12/16/81	Shaft	Weapons Related	Less than 20 kt	20		
Jornada	U-4j	1/28/82	Shaft	Weapons Related	139 kt	139		
Tenaja	U-3Lh	4/17/82	Shaft	Weapons Related	Less than 20 kt	20		
Kryddost	U-2co	5/6/82	Shaft	Weapons Related	Less than 20 kt	20		
Bouschet	U-3La	5/7/82	Shaft	Weapons Related	20 to 150 kt	150		
Kesti	U-9cn	6/16/82	Shaft	Weapons Related	Less than 20 kt	20		
Monterey	U-4aj	7/29/82	Shaft	Weapons Related	20 to 150 kt	150		
Atrisco	U-7bp	8/5/82	Shaft	Weapons Related	138 kt	138		
Queso	U-10bf	8/11/82	Shaft	Weapons Related	Less than 20 kt	20		

Detonation Name[a]	Hole Name[a]	Detonation Date[a]	Emplacement Type[a]	Purpose[a]	Announced Yield[a] (kt)	Max Yield (kt)	Comment[a,b]	Known radionuclide migration[e]
Cerro	U-3Lf	9/2/82	Shaft	Weapons Related	Less than 20 kt	20		
Frisco	U-8m	9/23/82	Shaft	Weapons Related	20 to 150 kt	150		
Borrego	U-7br	9/29/82	Shaft	Weapons Related	Less than 150 kt	150		
Seyval	U-3Lm	11/12/82	Shaft	Weapons Related	Less than 20 kt	20		
Manteca	U-4aL	12/10/82	Shaft	Weapons Related	20 to 150 kt	150		
Coalora	U-3Lo	2/11/83	Shaft	Weapons Related	Less than 20 kt	20		
Cheedam	U-2et	2/17/83	Shaft	Weapons Related	Less than 20 kt	20		
Turquoise	U-7bu	4/14/83	Shaft	Weapons Related	Less than 150 kt	150		
Armada	U-9cs	4/22/83	Shaft	Joint US-UK	Less than 20 kt	20		
Crowdie	U-2fe	5/5/83	Shaft	Weapons Related	Less than 20 kt	20		
Fahada	U-7bh	5/26/83	Shaft	Weapons Related	Less than 20 kt	20		
Danablu	U-2eu	6/9/83	Shaft	Weapons Related	Less than 20 kt	20		
Laban	U-2ff	8/3/83	Shaft	Weapons Related	Less than 20 kt	20		
Sabado	U-3Lc	8/11/83	Shaft	Weapons Related	Less than 20 kt	20		
Jarlsberg	U-10ca	8/27/83	Shaft	Weapons Related	Less than 20 kt	20		
Branco	U-2ew	9/21/83	Shaft	Weapons Related	Less than 20 kt	20	Simultaneous, same hole	
Branco-Herkimer	U-2ew	9/21/83	Shaft	Weapons Related	Less than 20 kt	20	Simultaneous, same hole	
Techado	U-4o	9/22/83	Shaft	Weapons Related	Less than 150 kt	150		
Navata	U-3Lb	9/29/83	Shaft	Safety Experiment	Less than 20 kt	20		
Muggins	U-3Ls	12/9/83	Shaft	Weapons Related	Less than 20 kt	20		
Romano	U-2ex	12/16/83	Shaft	Weapons Related	20 to 150 kt	150		
Gorbea	U-2cq	1/31/84	Shaft	Weapons Related	20 to 150 kt	150		
Tortugas	U-3gg	3/1/84	Shaft	Weapons Related	20 to 150 kt	150		
Agrini	U-2ev	3/31/84	Shaft	Weapons Related	Less than 20 kt	20	Accidental release of radioactivity detected onsite only	
Mundo	U-7bo	5/1/84	Shaft	Joint US-UK	20 to 150 kt	150		
Orkney	U-10be	5/2/84	Shaft	Weapons Related	Less than 20 kt	20		
Bellow	U-4ac	5/16/84	Shaft	Weapons Related	Less than 20 kt	20		
Caprock	U-4q	5/31/84	Shaft	Weapons Related	20 to 150 kt	150		
Duoro	U-3Lv	6/20/84	Shaft	Weapons Related	20 to 150 kt	150		
Normanna	U-10cb	7/12/84	Shaft	Weapons Related	Less than 20 kt	20		
Correo	U-3Lw	8/2/84	Shaft	Weapons Related	Less than 20 kt	20		
Dolcetto	U-7bi	8/30/84	Shaft	Weapons Related	Less than 20 kt	20		
Wexford	U-2cr	8/30/84	Shaft	Weapons Related	Less than 20 kt	20		
Breton	U-4ar	9/13/84	Shaft	Weapons Related	20 to 150 kt	150		
Vermejo	U-4r	10/2/84	Shaft	Weapons Related	Less than 20 kt	20		
Villita	U-3Ld	11/10/84	Shaft	Weapons Related	Less than 20 kt	20		
Minero	U-3Lt	12/20/84	Shaft	Weapons Related	Less than 20 kt	20		
Vaughn	U-3Lr	3/15/85	Shaft	Weapons Related	20 to 150 kt	150		
Cottage	U-8j	3/23/85	Shaft	Weapons Related	20 to 150 kt	150		
Hermosa	U-7bs	4/2/85	Shaft	Weapons Related	20 to 150 kt	150		

Detonation Name[a]	Hole Name[a]	Detonation Date[a]	Emplacement Type[a]	Purpose[a]	Announced Yield[a] (kt)	Max Yield (kt)	Comment[a,b]	Known radionuclide migration[e]
Ville	U-4am	6/12/85	Shaft	Weapons Related	Less than 20 kt	20		
Maribo	U-2cs	6/26/85	Shaft	Weapons Related	Less than 20 kt	20		
Cebrero	U-9cw	8/14/85	Shaft	Weapons Related	Less than 20 kt	20		
Chamita	U-3Lz	8/17/85	Shaft	Weapons Related	Less than 20 kt	20		
Ponil	U-7bv	9/27/85	Shaft	Weapons Related	Less than 20 kt	20		
Roquefort	U-4as	10/16/85	Shaft	Weapons Related	20 to 150 kt	150		
Abo	U-3mc	10/30/85	Shaft	Weapons Related	Less than 20 kt	20		
Kinibito	U-3me	12/5/85	Shaft	Joint US-UK	20 to 150 kt	150		
Glencoe	U-4i	3/22/86	Shaft	Weapons Related	29 kt	29	Operational release of radioactivity detected offsite	
Mogollon	U-3Li	4/20/86	Shaft	Weapons Related	Less than 20 kt	20		
Panamint	U-2gb	5/21/86	Shaft	Weapons Related	Less than 20 kt	20		
Tajo	U-7bL	6/5/86	Shaft	Weapons Related	20 to 150 kt	150		
Cornucopia	U-2gaS	7/24/86	Shaft	Weapons Related	Less than 20 kt	20		
Aleman	U-3kz	9/11/86	Shaft	Weapons Related	Less than 20 kt	20		Prompt injection from Sandreef (U-7aq)
Gascon	U-4t	11/14/86	Shaft	Weapons Related	20 to 150 kt	150		
Hazebrook-Apricot (Orange)	U-10bh	2/3/87	Shaft	Safety Experiment	Less than 20 kt	20	Simultaneous, same hole	
Hazebrook-Checkerberry (Red)	U-10bh	2/3/87	Shaft	Weapons Related	Less than 20 kt	20	Simultaneous, same hole	
Hazebrook-Emerald (Green)	U-10bh	2/3/87	Shaft	Weapons Related	Less than 20 kt	20	Simultaneous, same hole	
Tornero	U-3LL	2/11/87	Shaft	Weapons Related	Less than 20 kt	20		
Presidio	U-6d	4/22/87	Shaft	Weapons Related	Less than 20 kt	20		
Brie	U-10cc	6/18/87	Shaft	Weapons Related	Less than 20 kt	20		
Panchuela	U-3mg	6/30/87	Shaft	Weapons Related	Less than 20 kt	20		
Midland	U-7by	7/16/87	Shaft	Joint US-UK	20 to 150 kt	150		
Tahoka	U-3mf	8/13/87	Shaft	Weapons Related	20 to 150 kt	150		
Borate	U-2ge	10/23/87	Shaft	Weapons Related	20 to 150 kt	150		
Waco	U-3Lu	12/1/87	Shaft	Weapons Related	Less than 20 kt	20		
Abilene	U-3mn	4/7/88	Shaft	Weapons Related	Less than 20 kt	20		
Schellbourne	U-2gf	5/13/88	Shaft	Weapons Related	Less than 150 kt	150		
Laredo	U-3mh	5/21/88	Shaft	Weapons Related	Less than 150 kt	150		
Nightingale	U-2ey	6/22/88	Shaft	Safety Experiment	Less than 150 kt	150	Simulatneous with Rhyolite	
Rhyolite	U-2ey	6/22/88	Shaft	Weapons Related	Less than 150 kt	150	Simultaneous with Nightengale	
Harlingen-A	U-6g	8/23/88	Shaft	Weapons Related	Less than 20 kt	20	Simultaneous, separate holes	
Harlingen-B	U-6h	8/23/88	Shaft	Weapons Related	Less than 20 kt	20	Simultaneous, separate holes	
Bullfrog	U-4au	8/30/88	Shaft	Weapons Related	Less than 150 kt	150		
Dalhart	U-4u	10/13/88	Shaft	Weapons Related	Less than 150 kt	150		
Monahans-A	U-3Lk	11/9/88	Shaft	Weapons Related	Less than 20 kt	20	Simultaneous, separate holes	
Monahans-B	U-6i	11/9/88	Shaft	Weapons Related	Less than 20 kt	20	Simultaneous, separate holes	
Kawich A-Blue	U-8n	12/9/88	Shaft	Safety Expeirment	Less than 20 kt	20	Simultaneous, same hole	
Kawich A-White	U-8n	12/9/88	Shaft	Safety Experiment	Less than 20 kt	20	Simultaneous, same hole	
Texarkana	U-7ca	2/10/89	Shaft	Weapons Related	20 to 150 kt	150		

Detonation Name[a]	Hole Name[a]	Detonation Date[a]	Emplacement Type[a]	Purpose[a]	Announced Yield[a] (kt)	Max Yield (kt)	Comment[a,b]	Known radionuclide migration[e]
Kawich-Black	U-2cu	2/24/89	Shaft	Safety Experiment	Less than 20 kt	20	Simultaneous, same hole	
Kawich-Red	U-2cu	2/24/89	Shaft	Weapons Related	Less than 20 kt	20	Simultaneous, same hole	
Ingot	U-2gg	3/9/89	Shaft	Weapons Related	20 to 150 kt	150		
Palisade-1	U-4at	5/15/89	Shaft	Weapons Related	Less than 20 kt	20	Simultaneous, same hole	
Palisade-2	U-4at	5/15/89	Shaft	Safety Experiment	Less than 20 kt	20	Simultaneous, same hole	
Palisade-3	U-4at	5/15/89	Shaft	Safety Experiment	Less than 20 kt	20	Simultaneous, same hole	
Tulia	U-4s	5/26/89	Shaft	Weapons Related	Less than 20 kt	20		
Muleshoe	U-7bk	11/15/89	Shaft	Weapons Related	Less than 20 kt	20		
Whiteface-A	U-3Lp	12/20/89	Shaft	Safety Experiment	Less than 20 kt	20	Simultaneous, same hole	
Whiteface-B	U-3Lp	12/20/89	Shaft	Safety Experiment	Less than 20 kt	20	Simultaneous, same hole	
Metropolis	U-2gh	3/10/90	Shaft	Weapons Related	20 to 150 kt	150		
Bowie	U-3mk	4/6/90	Shaft	Weapons Related	Less than 20 kt	20		
Austin	U-6e	6/21/90	Shaft	Weapons Related	Less than 20 kt	20		
Sundown-A	U-1d	9/20/90	Shaft	Safety Experiment	Less than 20 kt	20	Simultaneous, same hole	
Sundown-B	U-1d	9/20/90	Shaft	Safety Experiment	Less than 20 kt	20	Simultaneous, same hole	
Ledoux	U-1a.01	9/27/90	Shaft	Weapons Related	Less than 20 kt	20		
Coso-Bronze	U-4an	3/8/91	Shaft	Weapons Related	Less than 20 kt	20	Simultaneous, same hole	
Coso-Gray	U-4an	3/8/91	Shaft	Weapons Related	Less than 20 kt	20	Simultaneous, same hole	
Coso-Silver	U-4an	3/8/91	Shaft	Safety Experiment	Less than 20 kt	20	Simultaneous, same hole	
Floydada	U-7cb	8/15/91	Shaft	Weapons Related	Less than 20 kt	20		
Lubbock	U-3mt	10/18/91	Shaft	Weapons Related	20 to 150 kt	150		
Bristol	U-4av	11/26/91	Shaft	Joint US-UK	Less than 20 kt	20		
Victoria	U-3kv	6/19/92	Shaft	Weapons Related	Less than 20 kt	20		
Galena-Green	U-9cv	6/23/92	Shaft	Safety Experiment	Less than 20 kt	20	Simultaneous, same hole	
Galena-Orange	U-9cv	6/23/92	Shaft	Safety Experiment	Less than 20 kt	20	Simultaneous, same hole	
Galena-Yellow	U-9cv	6/23/92	Shaft	Weapons Related	Less than 20 kt	20	Simultaneous, same hole	
Divider	U-3mL	9/23/92	Shaft	Weapons Related	Less than 20 kt	20		

[a]DOE/NV--209-Rev 15, as described in this report
[b]DOE/NV-346

Appendix B

Selected information for underground nuclear detonations in shafts and tunnels in the Yucca Flat /Climax Mine CAU, sorted by Working Point minus Water Level.

Appendix B

YFDB Identifier	Detonation Name[a]	Hole Name[a]	Water Level (WL) Depth[b] (m)	WP minus WL (m)	Saturated Test?	Calculated Cavity Radius (Rc)[c] (m)	WP Depth[d] (m)	WP-2Rc (m)	WP+2Rc (m)	WP HSU[e]	WP-2Rc HSU[e]	WP+ 2Rc HSU[e]
95	Natches	U-9ak #1	554	-495	no	56	59	-53	171	AA	AA	TMWTA
82	Paisano	U-9w #1	553	-495	no	57	58	-56	172	AA	AA	AA
102	Mullet	U-2ag	552	-492	no	56	60	-52	172	AA	AA	AA
71	Hatchie	U-9e	546	-485	no	56	61	-51	173	AA	AA	AA
67	Manatee	U-9af	543	-484	no	56	60	-52	172	AA	AA	AA
58	Tioga	U-9f	543	-484	no	56	59	-53	171	AA	AA	AA
227	Vigil	U-10ad	572	-481	no	51	91	-11	194	AA	AA	AA
249	Vito	U-10ab	571	-475	no	50	97	-3	197	AA	AA	AA
403	Piton-C	U-9 ITS AA-25	573	-472	no	49	101	3	199	TMLVTA	AA	LCA
381	Arabis-Blue	U-9 ITS Z-26	571	-470	no	49	101	3	199	TMLVTA	AA	TMLVTA
393	Hod-C (Blue)	U-9 ITS Z-25	570	-469	no	49	101	3	199	TMLVTA	AA	LCA
408	Scree-Chamois	U-9 ITS Z-24	569	-469	no	49	101	3	199	TMLVTA	AA	LCA
370	Fob-Blue	U-9 ITS Y-27	567	-467	no	49	101	3	199	TMLVTA	AA	TMLVTA
325	Valise	U-9by	548	-456	no	51	91	-11	193	AA	AA	AA
88	Apshapa	U-9ai	544	-455	no	51	89	-13	191	AA	AA	AA
139	Player	U-9cc	543	-453	no	51	90	-12	192	AA	AA	AA
156	Mudpack	U-10n	602	-450	no	23	152	106	198	TMLVTA	AA	TMLVTA
619	Seco	U-8L	646	-446	no	42	200	116	284	OSBCU	TMLVTA	OSBCU
135	Links	U-9bf	566	-445	no	47	120	26	214	AA	AA	TMWTA
99	Narraguagus	U-2f	589	-439	no	45	150	60	240	AA	AA	AA
122	Bogey	U-9au	557	-438	no	47	119	25	213	AA	AA	TMLVTA
357	Scuttle	U-2bh	602	-437	no	19	165	127	203	AA	AA	AA
165	Suede	U-9bk	581	-437	no	45	143	53	233	TMLVTA	AA	TMLVTA
25	Platypus	U-3ad	494	-436	no	57	58	-56	172	AA	AA	AA
137	Alva	U-2j	602	-436	no	26	166	114	218	AA	AA	AA
73	Carmel	U-2h	599	-435	no	44	163	75	251	AA	AA	AA
239	Oakland	U-2bi	601	-435	no	44	166	78	254	AA	AA	AA
72	Chipmunk	U-3ay	495	-435	no	56	59	-53	171	AA	AA	AA
205	Fenton	U-2m #1	601	-434	no	18	167	131	203	AA	AA	AA
61	St. Lawrence	U-2b	599	-433	no	44	166	78	254	AA	AA	AA
168	Chenille	U-9bg	569	-429	no	45	141	51	231	TMWTA	AA	TMLVTA
683	Cebrero	U-9cw	611	-428	no	43	183	97	269	TMLVTA	TMLVTA	LTCU
328	Gourd-Amber	U-2bf	606	-425	no	43	181	95	267	AA	AA	AA
163	Seersucker	U-9bm	568	-424	no	45	144	54	234	TMLVTA	AA	TMLVTA
155	Hoopoe	U-3cf	494	-424	no	54	70	-38	178	AA	AA	AA
9	San Juan	U-3p	495	-424	no	0	71	71	71	AA	AA	AA
292	Imp	U-2bj	602	-423	no	43	179	93	265	AA	AA	AA
27	Ermine	U-3ab	495	-422	no	54	73	-35	181	AA	AA	AA
57	Wolverine	U-3av	494	-421	no	53	73	-33	179	AA	AA	AA

Appendix B

YFDB Identifier	Detonation Name[a]	Hole Name[a]	Water Level (WL) Depth[b] (m)	WP minus WL (m)	Saturated Test?	Calculated Cavity Radius (Rc)[c] (m)	WP Depth[d] (m)	WP-2Rc (m)	WP+2Rc (m)	WP HSU[e]	WP-2Rc HSU[e]	WP+ 2Rc HSU[e]
79	Coypu	U-3af	495	-420	no	53	75	-31	181	AA	AA	AA
363	Tun-B	U-10am #2	613	-419	no	42	194	110	278	AA	AA	LTCU
3	Pascal-C	U-3e	496	-419	no	53	76	-30	182	AA	AA	AA
85	Tejon	U-3cg	494	-419	no	53	75	-31	181	AA	AA	AA
177	Pongee	U-2ah	553	-419	no	46	134	42	226	AA	AA	AA
148	Garden	U-9aj	568	-418	no	45	150	60	240	TMLVTA	AA	TMLVTA
201	Templar	U-9bt	568	-418	no	12	150	126	174	TMWTA	AA	TMLVTA
229	Rivet I	U-10aa	567	-415	no	45	152	62	242	AA	AA	AA
173	Organdy	U-9bo	588	-415	no	43	173	87	259	TMLVTA	TMLVTA	TMLVTA
364	Tun-C	U-10am #3	608	-414	no	42	194	110	278	TMLVTA	AA	LTCU
362	Tun-A	U-10am #1	611	-412	no	42	200	116	284	AA	AA	TMLVTA
118	Handicap	U-9ba	554	-410	no	45	144	54	234	AA	AA	TMLVTA
101	Tornillo	U-9aq	559	-409	no	12	150	126	174	AA	AA	TMLVTA
76	Toyah	U-9ac	538	-408	no	46	131	39	223	AA	AA	AA
324	Chatty	U-2bn	601	-406	no	42	195	111	279	AA	AA	AA
337	Bowl-1	U-2bo #1	603	-405	no	42	198	114	282	AA	AA	AA
257	Marvel	U-10dS #1	580	-404	no	21	176	134	218	AA	AA	TMLVTA
220	Tangerine	U-3eb	492	-404	no	51	88	-14	190	AA	AA	AA
142	Spoon	U-9bd	583	-403	no	43	180	94	266	TMLVTA	AA	TMLVTA
176	Izzer	U-9bp	565	-402	no	44	164	76	252	AA	AA	TMWTA
279	Crock	U-10ak	583	-401	no	43	182	96	268	AA	AA	TMLVTA
187	Kermet	U-2c	594	-398	no	42	196	112	280	AA	AA	AA
497	Seafoam	U-2ea	595	-397	no	42	198	114	282	AA	AA	AA
580	Asco	U-10bc	579	-397	no	43	183	97	269	TMLVTA	TMLVTA	ATCU
48	Wichita	U-9y	547	-397	no	45	150	60	240	AA	AA	AA
346	Kyack-B	U-2bq #2	582	-396	no	42	186	102	270	AA	AA	AA
10	Shrew	U-3ac	494	-396	no	50	98	-2	198	AA	AA	AA
666	Orkney	U-10be	606	-396	no	41	210	128	292	AA	AA	TUBA
125	Driver	U-9ar	543	-395	no	45	148	58	238	AA	AA	TMWTA
191	Maxwell	U-9br	578	-395	no	43	183	97	269	TMLVTA	AA	TMLVTA
11	Boomer	U-3aa	495	-394	no	49	101	3	199	AA	AA	AA
345	Kyack-A	U-2bq #1	586	-394	no	42	192	108	276	AA	AA	AA
711	Rhyolite	U-2ey	600	-393	no	81	207	45	369	AA	AA	LCA
555	Dofino	U-10ba	575	-392	no	43	183	97	269	AA	AA	AA
181	Centaur	U-2ak	561	-389	no	43	172	86	258	AA	AA	AA
8	Colfax	U-3k	495	-388	no	3	107	101	113	AA	AA	AA
34	Hudson	U-9n	539	-388	no	45	151	61	241	AA	AA	AA
285	Tub-C	U-10aj F	577	-388	no	42	189	105	273	AA	AA	TMLVTA
119	Pike	U-3cy	501	-387	no	48	115	19	211	AA	AA	AA

YFDB Identifier	Detonation Name[a]	Hole Name[a]	Water Level (WL) Depth[b] (m)	WP minus WL (m)	Saturated Test?	Calculated Cavity Radius (Rc)[c] (m)	WP Depth[d] (m)	WP-2Rc (m)	WP+2Rc (m)	WP HSU[e]	WP-2Rc HSU[e]	WP+ 2Rc HSU[e]
506	Potrero	U-2eb	597	-386	no	41	211	129	293	AA	AA	AA
283	Tub-A	U-10aj C	575	-386	no	42	189	105	273	AA	AA	TMLVTA
287	Tub-F	U-10aj A	575	-386	no	42	189	105	273	AA	AA	TMLVTA
473	Canna-Umbrinus	U-9 ITS YZ-26	568	-385	no	43	183	97	269	TMLVTA	TMLVTA	LCA
698	Hazebrook-Emerald (Green)	U-10bh	571	-385	no	42	186	102	270	AA	AA	AA
284	Tub-B	U-10aj B	573	-384	no	42	189	105	273	AA	AA	TMLVTA
126	Backswing	U-9aw	547	-384	no	44	163	75	251	AA	AA	TMLVTA
51	Raritan	U-9u	540	-384	no	44	156	68	244	AA	AA	AA
218	Saxon	U-2cc	536	-383	no	17	154	120	188	TMLVTA	AA	TMLVTA
504	Hulsea	U-2bx	577	-382	no	42	195	111	279	AA	AA	AA
112	Club	U-2aa	559	-379	no	43	180	94	266	AA	AA	AA
493	Polygonum	U-2by	592	-379	no	41	213	131	295	AA	AA	AA
161	Alpaca	U-2a	604	-379	no	10	225	205	245	AA	AA	AA
240	Heilman	U-2cg	531	-379	no	45	153	63	243	AA	AA	TMLVTA
219	Rovena	U-10s	572	-379	no	42	194	110	278	AA	AA	AA
585	Cremino	U-8e	588	-378	no	41	210	128	292	AA	AA	TMLVTA
46	Sacramento	U-9v	527	-378	no	45	149	59	239	AA	AA	AA
624	Havarti	U-10bg	578	-378	no	42	200	116	284	TMLVTA	TMLVTA	TMLVTA
96	Ahtanum	U-2L	604	-377	no	40	226	146	306	AA	AA	AA
524	Portola	U-10bb	575	-377	no	42	198	114	282	AA	AA	AA
104	Mustang	U-9at	542	-376	no	44	166	78	254	AA	AA	AA
108	Eagle	U-9av	541	-376	no	28	165	109	221	AA	AA	AA
238	Fizz	U-3fr	493	-376	no	48	117	22	214	AA	AA	AA
407	Scree-Alhambra	U-9 ITS Z-21	568	-375	no	42	192	108	276	TMLVTA	TMLVTA	LCA
298	Welder	U-3fs	493	-375	no	48	118	22	214	AA	AA	AA
302	Bit-B	U-3gt	493	-375	no	47	118	24	212	AA	AA	AA
602	Pera	U-10bd	575	-375	no	42	200	116	284	TMLVTA	AA	TMLVTA
288	Funnel	U-3ga	493	-375	no	47	119	25	213	AA	AA	AA
224	Simms	U-10w	573	-374	no	20	199	159	239	AA	AA	AA
170	Tee	U-2ab	564	-374	no	30	190	130	250	AA	AA	AA
462	Haplopappus	U-9 ITS W-22	558	-374	no	42	184	100	268	TMLVTA	TMLVTA	LTCU
246	Absinthe	U-3ep	492	-373	no	47	119	25	213	AA	AA	AA
268	Brush	U-3eq	492	-373	no	47	118	24	212	AA	AA	AA
329	Gourd-Brown	U-2bL	600	-373	no	40	227	147	307	AA	AA	AA
507	Plomo	U-3ff	522	-373	no	45	149	59	239	TMLVTA	TMLVTA	LTCU
254	Lexington	U-2bm	599	-373	no	40	226	146	306	AA	AA	TMLVTA
551	Sutter	U-2bw	573	-373	no	42	200	116	284	AA	AA	AA
35	Dead	U-9k	566	-372	no	42	194	110	278	AA	AA	TMLVTA
449	Mescalero	U-3gu	492	-372	no	47	120	26	214	AA	AA	AA

YFDB Identifier	Detonation Name[a]	Hole Name[a]	Water Level (WL) Depth[b] (m)	WP minus WL (m)	Saturated Test?	Calculated Cavity Radius (Rc)[c] (m)	WP Depth[d] (m)	WP-2Rc (m)	WP+2Rc (m)	WP HSU[e]	WP-2Rc HSU[e]	WP+ 2Rc HSU[e]
180	Ticking	U-9bj	582	-372	no	41	210	128	292	TMLVTA	AA	LTCU
38	Arikaree	U-9r	538	-372	no	44	166	78	254	AA	AA	AA
338	Bowl-2	U-2bo #2	600	-371	no	40	229	149	309	AA	AA	AA
424	Baneberry	U-8d	649	-371	no	30	278	218	338	TMLVTA	AA	TMLVTA
81	Kootanai	U-9w	552	-370	no	43	182	96	268	AA	AA	TMLVTA
30	Hoosic	U-9j	557	-370	no	23	187	141	233	TMLVTA	AA	TMLVTA
276	Throw	U-2bg	601	-370	no	40	231	151	311	AA	AA	AA
153	Drill (Target-Upper)	U-2ai	557	-369	no	23	188	142	234	AA	AA	AA
131	Fade	U-9be	574	-369	no	41	205	123	287	TMLVTA	AA	LTCU
195	Reo	U-10m	577	-369	no	41	208	126	290	AA	AA	AA
341	Spider-A	U-2bp #1	582	-369	no	41	213	131	295	AA	AA	TMLVTA
606	Norbo	U-8c	639	-368	no	39	271	193	349	OSBCU	TMLVTA	OSBCU
197	Cinnamon	U-3dm	487	-367	no	47	120	26	214	AA	AA	AA
120	Hook	U-9bc	571	-366	no	41	204	122	286	TMLVTA	TMLVTA	LTCU
158	Wool	U-9bh	582	-366	no	41	216	134	298	TMLVTA	TMWTA	LTCU
232	Rivet II	U-10z	563	-365	no	42	198	114	282	AA	AA	AA
399	Flask-Red	U-2az #3	518	-365	no	5	152	142	162	AA	AA	AA
93	Satsop	U-2g	590	-365	no	40	225	145	305	AA	AA	AA
206	Ochre	U-3ec	490	-363	no	47	126	32	220	AA	AA	AA
479	Alumroot	U-9cj	546	-363	no	43	183	97	269	AA	AA	AA
264	Polka	U-10ai	558	-363	no	42	195	111	279	AA	AA	AA
310	Bay Leaf	U-3gq	493	-363	no	46	130	38	222	AA	AA	AA
501	Pinedrops-Sloat	U-10as	576	-362	no	41	213	131	295	AA	AA	TMLVTA
710	Nightingale	U-2ey	600	-362	no	78	238	82	394	AA	AA	LCA
728	Muleshoe	U-7bk	606	-362	no	40	244	164	324	LTCU	TMLVTA	LTCU
80	Cumberland	U-2e	588	-361	no	40	227	147	307	AA	AA	AA
475	Solanum	U-9 ITS W-24.5	561	-360	no	42	201	117	285	TMLVTA	TMLVTA	TMLVTA
147	Turnstone	U-3dt	485	-359	no	47	126	32	220	AA	AA	AA
543	Rivoli	U-2eg	559	-359	no	42	200	116	284	AA	AA	AA
89	Hutia	U-3bc	492	-357	no	46	135	43	227	AA	AA	AA
31	Chinchilla II	U-3as	494	-357	no	46	137	45	229	AA	AA	AA
411	Truchas-Chamisal	U-3ho	475	-357	no	47	118	24	212	AA	AA	AA
410	Truchas-Chacon	U-3hn	475	-356	no	47	119	25	213	AA	AA	AA
350	Seaweed B	U-3hk-d	474	-356	no	47	119	25	213	AA	AA	TMWTA
5	Bernalillo	U-3n	495	-356	no	4	139	131	147	AA	AA	AA
14	Mad	U-9a	537	-356	no	12	182	158	206	AA	AA	AA
19	Stillwater	U-9c	537	-356	no	23	181	135	227	AA	AA	AA
347	Seaweed-C	U-3hk-e	473	-355	no	47	119	25	213	AA	AA	TMWTA
640	Queso	U-10bf	571	-354	no	41	216	134	298	AA	AA	TMLVTA

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426	Dexter	U-3hs	475	-354	no	47	120	26	214	AA	AA	AA
452	Sappho	U-2dh #2	552	-354	no	42	198	114	282	AA	AA	AA
732	Bowie	U-3mk	568	-354	no	41	213	131	295	TMLVTA	TMLVTA	LTCU
472	Canna-Limoges	U-9 ITS YZ-26	568	-354	no	41	213	131	295	TMLVTA	TMLVTA	LCA
56	Roanoke	U-9q	530	-354	no	43	177	91	263	AA	AA	AA
365	Tun-D	U-10am #4	610	-353	no	39	256	178	334	OSBCU	TMLVTA	OSBCU
316	Tyg-E	U-2dc #1	551	-353	no	42	198	114	282	AA	AA	AA
348	Seaweed-D	U-3hk-f	472	-353	no	47	119	25	213	AA	AA	TMWTA
342	Spider-B	U-2bp #2	581	-353	no	40	228	148	308	AA	AA	TMLVTA
54	Allegheny	U-9x	564	-353	no	41	211	129	293	TMWTA	AA	TMLVTA
460	Merida	U-2dn	556	-352	no	41	204	122	286	AA	AA	AA
546	Gouda	U-2ef	552	-352	no	42	200	116	284	AA	AA	AA
262	Worth	U-10ag	548	-351	no	42	197	113	281	AA	AA	AA
604	Azul	U-2em	556	-351	no	41	205	123	287	AA	AA	AA
113	Solendon	U-3cz	500	-350	no	45	150	60	240	AA	AA	AA
349	Seaweed-E	U-3hk-c	474	-350	no	47	124	30	218	AA	AA	TMWTA
4	Otero	U-3q	496	-350	no	6	146	134	158	AA	AA	AA
334	Ipecac-B	U-3hk-b	473	-349	no	47	124	30	218	AA	AA	TMWTA
333	Ipecac-A	U-3hk-a	472	-348	no	47	124	30	218	AA	AA	TMWTA
299	Vat	U-9cf	543	-348	no	42	195	111	279	AA	AA	TMWTA
7	Valencia	U-3r	495	-347	no	2	148	144	152	AA	AA	AA
6	Luna	U-3m	495	-347	no	2	148	144	152	AA	AA	AA
315	Tyg-D	U-2dc #2	553	-346	no	41	207	125	289	AA	AA	AA
22	Chinchilla	U-3ag	495	-345	no	20	150	110	190	AA	AA	AA
697	Hazebrook-Checkerberry (Red)	U-10bh	571	-345	no	40	226	146	306	AA	AA	LTCU
492	Silene	U-9ck	543	-345	no	42	198	114	282	AA	AA	AA
300	Hula	U-9bu	543	-345	no	42	198	114	282	AA	AA	AA
623	Pineau	U-7ao	552	-345	no	41	207	125	289	TMUVTA	AA	TMLVTA
222	Newark	U-10u	573	-344	no	40	229	149	309	AA	AA	TMLVTA
301	Bit-A	U-3gt	493	-344	no	45	148	58	238	AA	AA	AA
1	Pascal-A	U-3j	496	-344	no	45	152	62	242	AA	AA	AA
2	Pascal-B	U-3d	495	-342	no	45	152	62	242	AA	AA	AA
63	Anacostia	U-9i	569	-342	no	26	227	175	280	TMLVTA	TMLVTA	LTCU
121	Sturgeon	U-3bo	491	-342	no	45	150	60	240	AA	AA	AA
41	White	U-9b	534	-341	no	42	193	109	277	AA	AA	AA
533	Alviso	U-2du	522	-340	no	43	183	97	269	AA	AA	AA
272	Russet	U-6a	459	-340	no	47	120	26	214	AA	AA	AA
243	Effendi	U-2ap	560	-339	no	41	221	139	303	AA	AA	AA
152	Drill (Source-Lower)	U-2ai	557	-338	no	41	219	136	301	AA	AA	AA

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360	Culantro-A	U-3hi-a	472	-338	no	46	134	42	226	AA	AA	TMWTA
185	Elkhart	U-9bs	558	-338	no	41	220	138	302	TMWTA	AA	TMLVTA
114	Bunker	U-9bb	564	-338	no	40	226	146	306	TMLVTA	TMLVTA	TMLVTA
23	Codsaw	U-9g	550	-338	no	41	212	130	294	TMWTA	AA	TMLVTA
154	Cassowary	U-3bn	488	-337	no	45	150	60	240	AA	AA	AA
564	Gruyere	U-9cg	545	-337	no	41	207	125	289	AA	AA	AA
293	Rack	U-9ap	536	-336	no	42	200	116	284	AA	AA	AA
402	Piton-B	U-9 ITS X-27	564	-335	no	40	230	150	310	TMLVTA	TMLVTA	LTCU
467	Solano	U-3jx	468	-334	no	46	134	42	226	AA	AA	AA
36	Black	U-9p	549	-332	no	41	218	136	300	AA	AA	TMLVTA
401	Piton-A	U-9 ITS Y-30	568	-332	no	40	237	157	317	TMLVTA	TMLVTA	LCA
461	Capitan	U-3jj	465	-330	no	46	134	42	226	AA	AA	AA
482	Natoma	U-10aw	574	-330	no	40	244	164	324	AA	AA	AA
438	Frijoles-Espuela	U-3ju	479	-329	no	45	149	59	239	AA	AA	AA
87	Pleasant	U-9ah	540	-329	no	41	211	129	293	AA	AA	TMWTA
437	Frijoles-Deming	U-3jw	478	-328	no	45	150	60	240	AA	AA	AA
42	Raccoon	U-3ajS	493	-328	no	44	164	76	252	AA	AA	AA
91	Kennebec	U-2af	554	-328	no	40	226	146	306	AA	AA	AA
318	Packard	U-2u	575	-328	no	31	247	185	309	AA	AA	AA
534	Futtock	U-3eh	514	-328	no	42	187	103	271	AA	AA	AA
312	Tyg-A	U-2dc #4	556	-328	no	40	228	148	308	AA	AA	AA
434	Nama-Mephisto	U-9 ITS Z-27	571	-327	no	40	244	164	324	TMLVTA	TMLVTA	LCA
266	Hupmobile	U-2y	573	-326	no	28	247	191	303	AA	AA	AA
649	Armada	U-9cs	590	-325	no	39	265	187	343	LTCU	TMLVTA	LTCU
361	Culantro-B	U-3hi-b	473	-324	no	45	149	59	239	AA	AA	TMWTA
212	Discus Thrower	U-8a	661	-324	no	38	337	261	413	TMLVTA	TMLVTA	LCA3
314	Tyg-C	U-2dc #3	551	-323	no	40	228	148	308	AA	AA	AA
499	Spar	U-3jr	471	-322	no	45	148	58	238	AA	AA	AA
455	Jicarilla	U-3jm	470	-322	no	45	148	58	238	AA	AA	AA
391	Hod-A (Green)	U-9 ITS X-23	562	-321	no	40	241	161	321	TMLVTA	TMLVTA	LTCU
488	Cabresto	U-7h	519	-321	no	42	198	114	282	AA	AA	TMWTA
470	Akbar	U-10ax	588	-321	no	39	267	189	345	TMLVTA	TMLVTA	LTCU
487	Mesita	U-3jd	470	-321	no	45	149	59	239	AA	AA	AA
50	York	U-9z	546	-319	no	40	226	146	306	AA	AA	TMWTA
40	Eel	U-9m	536	-319	no	25	218	168	268	AA	AA	AA
637	Kesti	U-9cn	606	-318	no	38	288	212	364	LTCU	TMLVTA	OSBCU
160	Cashmere	U-2ad	550	-318	no	40	232	152	312	AA	AA	AA
659	Navata	U-3Lb	500	-317	no	43	183	97	269	AA	AA	AA
384	Cyathus	U-8b	611	-317	no	29	294	236	352	TMLVTA	TMLVTA	TMLVTA

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128	Ace	U-2n	579	-316	no	21	263	221	305	AA	AA	AA
132	Dub	U-10a	575	-316	no	33	259	193	325	AA	AA	AA
371	Fob-Green	U-9 ITS V-27	560	-315	no	40	244	164	324	TMLVTA	TMLVTA	TMLVTA
406	Scree-Acajou	U-9 ITS X-24	563	-314	no	39	249	171	327	TMLVTA	TMLVTA	LCA
471	Arsenate	U-9ci	562	-312	no	39	250	172	328	TMLVTA	TMWTA	LTCU
94	Kohocton	U-9ak	566	-312	no	39	255	177	333	TMLVTA	AA	TMLVTA
237	Mushroom	U-3ef	491	-312	no	43	180	94	266	AA	AA	TMUVTA
620	Vide	U-8k	635	-311	no	37	323	249	397	OSBCU	TMLVTA	OSBCU
233	Ward	U-10x	571	-311	no	39	260	182	338	AA	AA	TMLVTA
64	Taunton	U-9aa	539	-310	no	40	228	148	308	AA	AA	AA
174	Petrel	U-3dy	490	-310	no	17	181	147	215	AA	AA	AA
209	Tapestry	U-2an	557	-309	no	39	249	171	327	AA	AA	AA
383	Arabis-Red	U-9 ITS V-26	558	-308	no	39	250	172	328	TMLVTA	TMLVTA	LTCU
696	Hazebrook-Apricot (Orange)	U-10bh	571	-308	no	39	262	184	340	AA	AA	LTCU
74	Kaweah	U-9ab	534	-307	no	21	227	185	269	AA	AA	TMWTA
560	Forefoot	U-3kf	500	-307	no	42	194	110	278	AA	AA	AA
382	Arabis-Green	U-9 ITS X-28	565	-306	no	39	259	181	337	TMLVTA	TMLVTA	LCA
157	Parrot	U-3dk	486	-305	no	17	180	146	214	AA	AA	AA
129	Bitterling	U-3cu	497	-304	no	42	193	109	277	AA	AA	AA
313	Tyg-B	U-2dc #5	555	-304	no	39	251	173	329	AA	AA	AA
136	Trogon	U-3dj	497	-304	no	42	193	109	277	AA	AA	TMUVTA
190	Emerson	U-2aL	564	-304	no	39	260	182	338	AA	AA	AA
320	Biggin	U-9bz	545	-303	no	40	242	162	322	TMLVTA	AA	TMLVTA
33	Passaic	U-9L	536	-303	no	40	233	153	313	AA	AA	TMWTA
12	Mink	U-3ae	495	-303	no	42	192	108	276	AA	AA	AA
547	Sprit	U-3hc	486	-302	no	43	183	97	269	AA	AA	AA
169	Muscovy	U-3dx	482	-302	no	43	180	94	266	TMWTA	AA	TMLVTA
505	Sapello	U-3ge	482	-302	no	43	181	95	267	AA	AA	TMWTA
489	Kashan	U-10av	567	-301	no	39	265	187	343	AA	AA	TMLVTA
525	Portola-Larkin	U-10bb	575	-301	no	38	275	199	351	AA	AA	TMLVTA
207	Traveler	U-2cd	497	-300	no	42	198	114	282	AA	AA	LTCU
687	Abo	U-3mc	495	-299	no	42	196	112	280	AA	AA	AA
225	Ajax	U-9aL	537	-299	no	40	238	158	318	AA	AA	AA
286	Tub-D	U-10aj D	572	-299	no	38	273	197	349	TMLVTA	AA	LTCU
730	Whiteface-B	U-3Lp	481	-299	no	43	183	97	269	AA	AA	AA
522	Puddle	U-3kg	481	-298	no	43	183	97	269	AA	AA	AA
90	Mataco	U-3bk	493	-297	no	42	196	112	280	AA	AA	AA
355	Pod-C[f]	U-2ci	466	-296	no	26	171	119	223	AA	AA	TMLVTA
433	Nama-Amarylis	U-9 ITS XY-31	568	-295	no	38	273	197	349	LTCU	TMLVTA	LCA

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392	Hod-B (Red)	U-9 ITS X-20	560	-295	no	39	265	187	343	TMLVTA	TMLVTA	LTCU
457	Kara	U-2dh #3	554	-294	no	39	259	181	337	AA	AA	TMLVTA
404	Arnica-Violet	U-2dd #3	558	-294	no	39	264	186	342	AA	AA	AA
502	Pinedrops-Tawny	U-10as	576	-294	no	38	282	206	358	TMLVTA	AA	LCA
317	Tyg-F	U-2dc #6	559	-294	no	39	265	187	343	AA	AA	AA
563	Flotost	U-2ao	569	-294	no	38	275	199	351	AA	AA	TMWTA
182	Moa	U-3ed	487	-294	no	42	194	110	278	AA	AA	TMUVTA
236	Rivet III	U-10y	567	-294	no	38	274	198	350	AA	AA	LTCU
625	Islay	U-2er	587	-293	no	38	294	218	370	TMLVTA	AA	LTCU
556	Dofino-Lawton	U-10ba	575	-292	no	38	282	206	358	AA	AA	TMLVTA
198	Finfoot	U-3du	488	-292	no	42	196	112	280	AA	AA	AA
273	Pommard	U-3ee	501	-292	no	17	209	175	243	AA	AA	TMUVTA
172	Tweed	U-9bn	576	-292	no	38	284	208	360	TMLVTA	TMLVTA	TMLVTA
372	Fob-Red	U-9 ITS V-24	556	-290	no	39	266	188	344	TMLVTA	TMLVTA	LTCU
526	Teleme	U-9cL	594	-289	no	37	305	231	379	LTCU	TMLVTA	LTCU
514	Crestlake-Tansan	U-2dw	560	-288	no	39	272	194	350	AA	AA	AA
652	Danablu	U-2eu	607	-287	no	37	320	246	394	AA	AA	AA
111	Oconto	U-9ay	552	-287	no	31	265	203	327	TMLVTA	TMWTA	TMLVTA
49	Bobac	U-3bL	492	-286	no	41	206	124	288	AA	AA	AA
621	Aligote	U-7bg	606	-286	no	37	320	246	394	LTCU	LTCU	OSBCU
159	Tern	U-3dw	495	-284	no	41	211	129	293	AA	AA	TMUVTA
729	Whiteface-A	U-3Lp	481	-284	no	42	197	113	281	AA	AA	AA
561	Carnelian	U-4af	492	-284	no	41	208	126	290	AA	AA	LCA3
226	Cerise	U-3eu	494	-283	no	41	211	129	293	AA	AA	TMWTA
508	Jib	U-3hb	463	-283	no	43	180	94	266	TMUVTA	AA	TMWTA
430	Bracken	U-10aq	585	-280	no	37	305	231	379	LTCU	TMLVTA	OSBCU
616	Dauphin	U-9cq	600	-280	no	37	320	246	394	LTCU	LTCU	OSBCU
591	Baccarat	U-7ax	606	-280	no	37	326	252	400	OSBCU	LTCU	OSBCU
387	Can-Green	U-2dd #1	554	-279	no	83	274	108	440	AA	AA	LTCU
706	Waco	U-3Lu	461	-278	no	43	183	97	269	AA	AA	TMWTA
196	Plaid II	U-2r	546	-277	no	39	269	191	347	AA	AA	AA
28	Brazos	U-9d	535	-276	no	29	259	201	317	AA	AA	AA
52	Hyrax	U-3bh	491	-274	no	41	217	135	299	AA	AA	AA
353	Pod-A[f]	U-2ck	540	-274	no	24	267	219	315	TMLVTA	TMLVTA	TMLVTA
746	Galena-Yellow	U-9cv	563	-273	no	38	290	214	366	LTCU	TMLVTA	OSBCU
421	Avens-Cream	U-9 ITS X-29	566	-273	no	38	293	217	369	LTCU	TMLVTA	LCA
537	Leyden	U-9cm	597	-271	no	37	326	252	400	LTCU	TMLVTA	OSBCU
466	Cuchillo	U-3jt	469	-271	no	42	199	115	283	AA	AA	AA
494	Waller	U-2bz	582	-271	no	37	311	237	385	AA	AA	TMLVTA

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444	Lagoon	U-10ar	575	-270	no	37	305	231	379	AA	AA	OSBCU
247	Switch	U-9bv	572	-270	no	20	302	262	342	LTCU	TMLVTA	ATCU
596	Chess	U-7at	604	-269	no	37	335	261	409	LTCU	LTCU	OSBCU
451	Dianthus	U-10at	572	-267	no	37	305	231	379	AA	AA	TMLVTA
469	Delphinium	U-2dp	562	-267	no	34	296	228	364	AA	AA	AA
307	Auger	U-3fx	507	-266	no	40	240	160	320	TMLVTA	TMLVTA	TMLVTA
217	Vulcan	U-2bd	588	-266	no	40	322	242	402	AA	AA	TMLVTA
664	Agrini	U-2ev	584	-264	no	37	320	246	394	AA	AA	AA
574	Rib	U-3jv	477	-264	no	41	213	131	295	AA	AA	AA
66	Numbat	U-3bu	494	-262	no	40	232	152	312	AA	AA	TMUVTA
204	Tomato	U-3ek	489	-262	no	40	226	146	306	TMLVTA	TMWTA	TSA
332	Aliment	U-3gj	503	-262	no	40	240	160	320	OSBCU	LTCU	OSBCU
223	Khaki	U-3et	495	-262	no	40	233	153	313	AA	AA	TMUVTA
445	Parnassia	U-2bc	592	-261	no	37	331	257	405	TMLVTA	AA	LTCU
271	Torch	U-3fj	501	-261	no	40	240	160	320	TMWTA	TMUVTA	TMLVTA
627	Cernada	U-3kk	473	-260	no	41	213	131	295	AA	AA	AA
352	Cruet	U-2cn	523	-259	no	32	264	200	328	TMWTA	AA	TMLVTA
453	Ocate	U-3jp	469	-259	no	41	210	128	292	AA	AA	AA
53	Peba	U-3bb	499	-258	no	40	241	161	321	AA	AA	AA
274	Bevel	U-3fu	498	-258	no	40	241	161	321	AA	AA	AA
548	Chevre	U-10ay	572	-255	no	37	317	243	391	AA	AA	TMLVTA
260	Cognac	U-3fm	495	-255	no	40	240	160	320	AA	AA	AA
186	Sepia	U-3en	496	-255	no	40	241	161	321	AA	AA	AA
440	Frijoles-Petaca	U-3hz	479	-254	no	40	226	146	306	AA	AA	AA
20	Armadillo	U-3ar	492	-252	no	28	240	184	296	AA	AA	AA
29	Hognose	U-3ai	492	-252	no	40	240	160	320	AA	AA	AA
84	Harkee	U-3bv	492	-251	no	40	241	161	321	AA	AA	TMUVTA
127	Minnow	U-3cv	492	-251	no	40	241	161	321	AA	AA	TMLVTA
303	File	U-3gb	479	-250	no	40	229	149	309	AA	AA	AA
420	Avens-Asamlte	U-9 ITS W-21	557	-249	no	37	308	234	382	LTCU	TMLVTA	OSBCU
641	Cerro	U-3Lf	478	-249	no	40	229	149	309	AA	AA	AA
228	Sidecar	U-3ez	489	-249	no	40	240	160	320	TMWTA	AA	TMLVTA
418	Avens-Alkermes	U-9 ITS U-24	554	-248	no	37	306	232	380	TMLVTA	TMLVTA	LTCU
62	Gundi	U-3bm	489	-248	no	40	241	161	321	AA	AA	AA
59	Bandicoot	U-3bj	489	-247	no	34	241	173	309	AA	AA	AA
282	Wembley	U-3ey	485	-247	no	40	238	158	318	AA	AA	TMUVTA
431	Apodaca	U-3gs	487	-246	no	40	241	161	321	LTCU	TMWTA	LTCU
69	Casselman	U-10g	549	-246	no	38	303	227	379	AA	AA	AA
78	Ferret Prime	U-3by	487	-245	no	40	241	161	321	AA	AA	AA

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256	Gilroy	U-3ex	485	-245	no	40	240	160	320	AA	AA	AA
405	Arnica-Yellow	U-2dd #2	554	-244	no	37	309	235	383	TMLVTA	AA	TMLVTA
673	Wexford	U-2cr	558	-244	no	37	314	240	388	TMLVTA	TMLVTA	TMLVTA
575	Campos	U-9cp	564	-244	no	37	320	246	394	TMLVTA	TMLVTA	LTCU
396	Manzanas	U-3gr	485	-244	no	40	241	161	321	TSA	TMLVTA	OSBCU
344	Pliers	U-3gn	481	-242	no	40	239	159	319	AA	AA	AA
319	Shave	U-3gk	483	-242	no	40	241	161	321	UTCU	TMLVTA	LTCU
647	Cheedam	U-2et	585	-242	no	36	343	271	415	TMLVTA	TMLVTA	ATCU
278	Hatchet	U-3fz	482	-241	no	40	240	160	320	AA	AA	AA
458	Zinnia	U-2dk	563	-240	no	37	323	249	397	AA	AA	AA
590	Concentration	U-3kn	483	-240	no	40	243	163	323	AA	AA	AA
203	Stutz	U-2ca	466	-240	no	40	226	146	306	TMLVTA	AA	LTCU
242	Chocolate	U-3es	480	-239	no	40	240	160	320	AA	AA	AA
735	Sundown-B	U-1d	495	-239	no	39	256	178	334	AA	AA	AA
463	Tajique	U-7aa	571	-239	no	37	332	258	406	LTCU	LTCU	OSBCU
323	Winch	U-3gf	479	-239	no	40	240	160	320	TMWTA	AA	TMWTA
251	Gibson	U-3ew	479	-238	no	40	241	161	321	AA	AA	TMWTA
660	Muggins	U-3Ls	482	-238	no	40	244	164	324	TMUVTA	AA	TMWTA
603	Backgammon	U-3jh	466	-237	no	40	229	149	309	AA	AA	AA
677	Minero	U-3Lt	481	-237	no	40	245	165	325	TMUVTA	AA	TMWTA
541	Shallows	U-3jf	481	-237	no	40	245	165	325	AA	AA	TMUVTA
707	Abilene	U-3mn	481	-236	no	40	245	165	325	TMUVTA	AA	TMLVTA
281	Adze	U-3fw	475	-235	no	40	240	160	320	TSA	TMWTA	LTCU
653	Laban	U-2ff	561	-235	no	37	326	252	400	AA	AA	TMLVTA
24	Cimarron	U-9h	539	-235	no	31	305	243	367	AA	AA	AA
311	Scissors	U-3gh	475	-235	no	40	240	160	320	AA	AA	TMWTA
446	Chaenactis	U-2dL	565	-234	no	79	331	173	489	AA	AA	AA
17	Agouti	U-3ao	494	-233	no	27	261	207	315	AA	AA	AA
37	Paca	U-3ax	492	-233	no	39	258	180	336	AA	AA	AA
456	Longchamps	U-2dm	560	-233	no	37	326	252	400	AA	AA	AA
500	Pinedrops-Bayou	U-10as	576	-233	no	36	343	271	415	TMLVTA	AA	LCA
416	Corazon	U-3ha	474	-233	no	40	241	161	321	AA	AA	TMWTA
481	Gazook	U-2do	558	-232	no	37	326	252	400	AA	AA	TMLVTA
105	Greys	U-9ax	533	-232	no	81	301	139	463	AA	AA	TMLVTA
60	Santee	U-10f	551	-232	no	37	319	245	393	AA	AA	AA
68	Acushi	U-3bg	492	-231	no	39	261	183	339	AA	AA	AA
106	Barracuda	U-3cr	495	-231	no	39	263	185	341	AA	AA	TMLVTA
441	Chantilly	U-2di	562	-231	no	37	331	257	405	AA	AA	AA
44	Daman I	U-3be	491	-231	no	39	260	182	338	AA	AA	AA

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43	Packrat	U-3aw	492	-230	no	39	262	184	340	AA	AA	AA
32	Dormouse Prime	U-3az	490	-230	no	32	261	197	325	AA	AA	AA
681	Ville	U-4am	520	-229	no	38	291	215	367	TMLVTA	AA	LTCU
146	Barbel	U-3bx	488	-229	no	39	259	181	337	AA	AA	TMWTA
485	Colmor	U-3hv	475	-229	no	40	246	166	326	AA	AA	AA
241	Fawn	U-3eo	500	-229	no	39	271	193	349	AA	AA	AA
103	Anchovy	U-3bq	488	-228	no	39	260	182	338	AA	AA	TMUVTA
656	Branco	U-2ew	520	-227	no	38	293	217	369	AA	AA	TMWTA
124	Pipefish	U-3co	488	-226	no	39	262	184	340	AA	AA	AA
107	Sardine	U-3ch	489	-226	no	39	262	184	340	AA	AA	AA
83	Gundi Prime	U-3db	498	-226	no	39	272	194	350	AA	AA	TMLVTA
100	Grunion	U-3bz	487	-226	no	39	261	183	339	AA	AA	AA
269	Mallet	U-3fv	465	-225	no	40	240	160	320	AA	AA	TMUVTA
322	Nipper	U-3gL	466	-225	no	40	241	161	321	AA	AA	TMUVTA
565	Gruyere-Gradino	U-9cg	545	-225	no	37	320	246	394	AA	AA	TMWTA
734	Sundown-A	U-1d	495	-224	no	39	270	192	348	AA	AA	AA
290	Spud	U-3fy	464	-223	no	40	240	160	320	TMLVTA	AA	TSA
743	Victoria	U-3kv	468	-223	no	40	244	164	324	AA	AA	TMUVTA
509	Grove	U-2ds	537	-223	no	37	314	240	388	TMLVTA	AA	TMLVTA
439	Frijoles-Guaje	U-3hf	479	-222	no	39	257	179	335	AA	AA	TMUVTA
651	Fahada	U-7bh	606	-222	no	35	384	314	454	OSBCU	LTCU	OSBCU
690	Mogollon	U-3Li	481	-221	no	39	259	181	337	TMUVTA	AA	TMWTA
583	Satz	U-2dq	536	-221	no	37	315	241	389	TMLVTA	AA	TMLVTA
422	Canjilon	U-3fq	522	-219	no	38	302	226	378	TMLVTA	TMWTA	LTCU
622	Niza	U-9cr	560	-219	no	36	341	269	413	LTCU	TMLVTA	OSBCU
646	Coalora	U-3Lo	492	-218	no	38	274	198	350	TMUVTA	AA	TMWTA
141	Guanay	U-3di	478	-217	no	39	261	183	339	AA	AA	AA
550	Asiago	U-2ar	545	-215	no	37	330	256	404	AA	AA	AA
275	Noor	U-2be	596	-214	no	76	382	230	534	AA	AA	TMLVTA
474	Tuloso	U-3gi	483	-212	no	39	271	193	349	AA	AA	AA
193	Sienna	U-3cj	487	-212	no	38	275	199	351	AA	AA	TMUVTA
667	Bellow	U-4ac	418	-211	no	41	207	125	289	TMLVTA	AA	TMLVTA
432	Barranca	U-3he	481	-210	no	39	271	193	349	AA	AA	AA
77	Gerbil	U-3bp	489	-210	no	38	280	204	356	AA	AA	TMWTA
412	Truchas-Rodarte	U-3hm	476	-209	no	39	266	188	344	AA	AA	AA
389	Snubber	U-3ev-2S	551	-207	no	31	344	282	406	LTCU	LTCU	OSBCU
134	Cormorant	U-3df	478	-206	no	39	272	194	350	AA	AA	AA
414	Penasco	U-3hL	475	-204	no	39	271	193	349	AA	AA	TMWTA
672	Dolcetto	U-7bi	568	-203	no	36	365	293	437	LTCU	LTCU	OSBCU

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304	Crew	U-2db	561	-203	no	77	359	205	513	AA	AA	AA
305	Crew-2nd	U-2db	561	-203	no	36	359	287	431	AA	AA	AA
162	Merlin	U-3ct	497	-201	no	30	296	236	356	AA	AA	TMUVTA
356	Pod-D[f]	U-2cj	512	-200	no	23	312	266	358	TMLVTA	TMLVTA	LTCU
650	Crowdie	U-2fe	590	-200	no	35	390	320	460	AA	AA	AA
415	Carrizozo	U-3hr	477	-198	no	38	279	203	355	TMWTA	AA	TMWTA
115	Bonefish	U-3bt	498	-197	no	38	301	225	377	AA	AA	AA
150	Handcar	U-10b	598	-195	no	29	403	345	461	LCA	LCA	LCA
354	Pod-B[f]	U-2ch	444	-195	no	24	249	201	297	TMLVTA	TMLVTA	LTCU
395	Cornice-Yellow	U-10ap #1	584	-194	no	76	390	238	542	OSBCU	TMLVTA	OSBCU
577	Karab	U-4ah	525	-194	no	37	331	257	405	LTCU	TMLVTA	ATCU
297	Knife C	U-3er	495	-194	no	38	301	225	377	LTCU	AA	LTCU
65	Tendrac	U-3ba	496	-194	no	38	303	227	379	AA	AA	AA
605	Tarko	U-2fd	561	-193	no	36	369	297	441	AA	AA	AA
454	Onaja	U-3js	471	-192	no	38	279	203	355	AA	AA	AA
685	Ponil	U-7bv	556	-191	no	36	365	293	437	LTCU	LTCU	OSBCU
208	Cyclamen	U-3cx	496	-191	no	32	305	241	369	AA	AA	AA
495	Bernal	U-3jy	475	-190	no	38	285	209	361	AA	AA	AA
16	Stoat	U-3ap	493	-190	no	24	302	254	350	AA	AA	AA
75	Jerboa	U-3at	491	-190	no	38	301	225	377	AA	AA	AA
484	Velarde	U-3jk	465	-188	no	38	277	201	353	AA	AA	AA
736	Ledoux	U-1a.01	479	-188	no	38	291	215	367	AA	AA	AA
92	Pekan	U-3bw	490	-188	no	38	302	226	378	AA	AA	TMLVTA
632	Caboc	U-2cp	522	-187	no	37	335	261	409	TMLVTA	TMWTA	TMLVTA
496	Pajara	U-3ji	465	-187	no	38	278	202	354	AA	AA	AA
513	Crestlake-Briar	U-2dw	560	-186	no	36	374	302	446	AA	AA	TMLVTA
693	Cornucopia	U-2gaS	566	-185	no	35	380	310	450	AA	AA	AA
465	Cebolla	U-3jc	472	-185	no	38	287	211	363	AA	AA	TMUVTA
745	Galena-Orange	U-9cv	563	-183	no	35	380	310	450	OSBCU	LTCU	OSBCU
261	Sazerac	U-3fa	485	-183	no	38	301	225	377	AA	AA	AA
521	Temescal	U-4ab	445	-183	no	39	263	185	341	AA	AA	LCA3
373	Ajo	U-3gd	486	-182	no	37	304	230	378	AA	AA	AA
699	Tornero	U-3LL	480	-182	no	38	298	222	374	TMWTA	TMUVTA	TMWTA
425	Embudo	U-3hd	484	-181	no	38	303	227	379	AA	AA	TMLVTA
400	Flask-Yellow	U-2az #2	516	-181	no	6	335	323	347	AA	AA	AA
722	Kawich-Red	U-2cu	551	-181	no	36	370	298	442	TMLVTA	TMLVTA	TMLVTA
626	Trebbiano	U-3Lj	486	-181	no	37	305	231	379	TMUVTA	AA	TMWTA
635	Kryddost	U-2co	516	-180	no	37	335	261	409	TMLVTA	TMLVTA	TMLVTA
145	Par	U-2p	586	-180	no	43	406	320	492	AA	AA	AA

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447	Hospah	U-3je	482	-180	no	38	302	226	378	AA	AA	AA
464	Atarque	U-3ht	474	-179	no	38	294	218	370	AA	AA	TMWTA
235	Persimmon	U-3dn	476	-177	no	38	299	223	375	AA	AA	TMWTA
291	Tanya	U-2dt	557	-176	no	76	381	229	533	AA	AA	LCA
183	Screamer	U-3dg	478	-176	no	38	302	226	378	TMWTA	AA	TMLVTA
419	Avens-Andorre	U-9 ITS T-28	555	-176	no	35	379	309	449	LTCU	TMLVTA	LTCU
326	Barsac	U-3gc	480	-176	no	37	304	230	378	AA	AA	AA
70	Ferret	U-3bf	502	-176	no	37	326	252	400	TMUVTA	AA	TMWTA
133	Bye	U-10i	566	-175	no	76	391	239	543	LTCU	TMLVTA	LCA
149	Forest	U-7a	562	-175	no	35	387	317	457	LTCU	TMLVTA	LTCU
582	Jackpots	U-3kj	479	-175	no	37	304	230	378	AA	AA	AA
443	Cathay	U-9ch	552	-174	no	35	378	308	448	TMLVTA	TMLVTA	TMLVTA
716	Monahans-A	U-3Lk	463	-173	no	38	290	214	366	AA	AA	AA
712	Harlingen-A	U-6g	463	-173	no	38	290	214	366	AA	AA	AA
713	Harlingen-B	U-6h	462	-173	no	38	290	214	366	AA	AA	AA
717	Monahans-B	U-6i	462	-173	no	38	290	214	366	AA	AA	AA
248	Umber	U-3em	482	-172	no	30	310	250	370	AA	AA	AA
336	Tapper	U-3go	475	-172	no	38	303	227	379	AA	AA	AA
719	Kawich A-White	U-8n	540	-171	no	36	369	297	441	LTCU	TMLVTA	OSBCU
523	Keel	U-3hu	473	-169	no	37	305	231	379	AA	AA	TMWTA
607	Liptauer	U-2eh	585	-168	no	68	417	281	553	AA	AA	AA
586	Cremino-Caerphilly	U-8e	588	-168	no	35	420	350	490	TMLVTA	TMLVTA	TMLVTA
385	Jal	U-3hh	469	-167	no	38	301	225	377	AA	AA	AA
737	Coso-Bronze	U-4an	500	-166	no	37	333	259	407	TMWTA	AA	LTCU
450	Cowles	U-3hx	468	-166	no	38	302	226	378	AA	AA	AA
682	Maribo	U-2cs	547	-166	no	35	381	311	451	TMLVTA	TMLVTA	TMLVTA
265	Stilt	U-3fh	497	-164	no	37	333	259	407	TMLVTA	TMLVTA	LTCU
143	Courser	U-3do	523	-164	no	0	359	359	359	LTCU	LTCU	LTCU
744	Galena-Green	U-9cv	563	-163	no	35	400	330	470	OSBCU	LTCU	OSBCU
709	Laredo	U-3mh	515	-163	no	71	351	209	493	LTCU	LTCU	OSBCU
230	Nash	U-2ce	527	-163	no	45	364	274	454	LCA3	TMLVTA	LCA3
747	Divider	U-3mL	503	-163	no	36	340	268	412	LTCU	LTCU	OSBCU
517	Pratt	U-3hq	476	-162	no	37	314	240	388	AA	AA	AA
611	Huron King	U-3ky	481	-161	no	37	320	246	394	AA	AA	AA
179	Mauve	U-3dp	479	-158	no	37	321	247	395	AA	AA	AA
554	Oarlock	U-3km	476	-158	no	37	318	244	392	AA	AA	AA
448	Yerba	U-1c	490	-158	no	37	332	258	406	AA	AA	AA
289	Sevilla	U-3fk	516	-157	no	36	359	287	431	TMLVTA	TMLVTA	LTCU
98	Carp	U-3cb	486	-157	no	37	329	255	403	AA	AA	TMLVTA

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718	Kawich A-Blue	U-8n	540	-156	no	35	384	314	454	OSBCU	TMLVTA	OSBCU
388	Can-Red	U-2dd #4	554	-155	no	75	399	249	549	LTCU	AA	LCA
724	Palisade-1	U-4at	490	-155	no	37	335	261	409	TMLVTA	TMLVTA	TMLVTA
369	Terrine-Yellow	U-9bi #2	572	-154	no	75	418	268	568	LTCU	TMLVTA	OSBCU
702	Panchuela	U-3mg	473	-154	no	37	319	245	393	AA	AA	TMUVTA
86	Stones	U-9ae	547	-154	no	76	393	241	545	TMLVTA	AA	LTCU
609	Canfield	U-3kx	504	-153	no	36	351	279	423	TMLVTA	TMLVTA	LTCU
527	Bilge	U-3kc	470	-152	no	37	318	244	392	AA	AA	AA
140	Haddock	U-3dL	515	-151	no	36	364	292	436	LTCU	TMLVTA	LTCU
295	Knife A	U-3fb	483	-151	no	37	332	258	406	TMLVTA	AA	LTCU
116	Mackerel	U-4b	484	-150	no	37	334	260	408	TMLVTA	TMWTA	TMLVTA
194	Dovekie	U-3cd	483	-150	no	37	333	259	407	AA	AA	TMLVTA
670	Normanna	U-10cb	350	-150	no	42	200	116	284	LTCU	AA	LCCU
199	Clymer	U-9ce	546	-149	no	35	397	327	467	AA	AA	TMWTA
520	Estaca	U-3ja	470	-149	no	37	321	247	395	TMUVTA	AA	TMWTA
378	Yannigan-Blue	U-2ay #3	510	-147	no	77	364	210	518	AA	AA	TMWTA
536	Deck	U-3kd	472	-146	no	37	326	252	400	AA	AA	TMUVTA
253	Bordeaux	U-3dr	477	-145	no	37	332	258	406	AA	AA	AA
530	Edam	U-2dy	556	-144	no	75	411	261	561	TMLVTA	AA	LCA
684	Chamita	U-3Lz	475	-144	no	37	332	258	406	TMUVTA	AA	TMWTA
478	Flax-Test	U-2dj	577	-141	no	74	436	288	584	AA	AA	AA
654	Sabado	U-3Lc	461	-141	no	37	320	246	394	UTCU	TMWTA	LTCU
671	Correo	U-3Lw	475	-141	no	37	334	260	408	TMLVTA	TMUVTA	LTCU
553	Cove	U-3ki	474	-139	no	37	335	261	409	AA	AA	AA
700	Presidio	U-6d	458	-138	no	37	320	246	394	TMLVTA	TMWTA	TSA
376	Labis	U-10an	580	-138	no	37	442	368	516	LTCU	TMLVTA	OSBCU
610	Flora	U-3Lg	472	-137	no	37	335	261	409	AA	AA	AA
519	Trumbull	U-4aa	400	-137	no	39	263	185	341	TMLVTA	AA	LCA3
200	Purple	U-3ds	469	-137	no	37	333	259	407	TMWTA	AA	TMLVTA
394	Cornice-Green	U-10ap #3	580	-136	no	73	443	297	589	LTCU	TMLVTA	LCA
435	Baltic	U-9 ITS S-25	547	-135	no	35	412	342	482	TMLVTA	TMLVTA	LTCU
130	Duffer	U-10dS	580	-134	no	34	447	379	515	LTCU	TMLVTA	OSBCU
662	Gorbea	U-2cq	521	-133	no	69	388	250	526	TMLVTA	TMLVTA	ATCU
476	Flax-Backup	U-2dj	577	-132	no	34	445	377	513	AA	AA	AA
642	Frisco	U-8m	583	-132	no	66	451	319	583	OSBCU	TMLVTA	OSBCU
595	Freezeout	U-3kw	466	-131	no	37	335	261	409	AA	AA	TMUVTA
18	Dormouse	U-3aq	493	-130	no	36	363	291	435	AA	AA	AA
13	Fisher	U-3ah	492	-128	no	31	364	302	426	AA	AA	AA
343	Horehound	U-3gm	460	-128	no	37	332	258	406	LTCU	TSA	LTCU

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380	Yannigan-White	U-2ay #2	523	-128	no	76	395	243	547	AA	AA	TMLVTA
15	Ringtail	U-3ak	490	-127	no	36	363	291	435	AA	AA	TMUVTA
26	Pampas	U-3aL	490	-127	no	28	363	307	419	AA	AA	AA
655	Jarlsberg	U-10ca	325	-126	no	42	200	116	284	TMLVTA	AA	OSBCU
491	Portulaca	U-2bv	591	-125	no	73	466	320	612	AA	AA	AA
701	Brie	U-10cc	326	-123	no	41	203	121	285	LTCU	AA	LCCU
618	Clairette	U-3kr	475	-122	no	36	354	282	426	AA	AA	AA
721	Kawich-Black	U-2cu	551	-120	no	34	431	363	499	TMLVTA	TMLVTA	LCA3
216	Kankakee	U-10p	575	-120	no	73	455	309	601	LCA	AA	LCA
594	Memory	U-3kq	485	-120	no	36	365	293	437	AA	AA	AA
308	Knife B	U-3dz	482	-119	no	36	363	291	435	AA	AA	AA
579	Topmast	U-7ay	576	-118	no	34	458	390	526	OSBCU	LTCU	OSBCU
175	Tiny Tot	U-15e	228	-117	no	48	111	15	207	MGCU	MGCU	MGCU
675	Vermejo	U-4r	467	-117	no	36	350	278	422	TMUVTA	AA	TMWTA
379	Yannigan-Red	U-2ay #1	508	-116	no	76	392	240	544	AA	AA	TMWTA
267	Staccato	U-10ah	559	-116	no	73	443	297	589	AA	AA	OSBCU
644	Seyval	U-3Lm	481	-115	no	36	366	294	438	AA	AA	AA
634	Tenaja	U-3Lh	470	-114	no	36	356	284	428	TMLVTA	TMWTA	LTCU
390	Beebalm	U-3fn	503	-112	no	35	390	320	460	TMWTA	AA	LTCU
679	Cottage	U-8j	627	-112	no	64	515	387	643	OSBCU	LTCU	LCA
417	Artesia	U-7x	595	-110	no	72	485	341	629	LTCU	LTCU	ATCU
612	Verdello	U-3ku	476	-110	no	36	366	294	438	AA	AA	TMUVTA
613	Bonarda	U-3gv	490	-109	no	69	381	243	519	TMWTA	AA	LTCU
572	Seamount	U-3kp	479	-109	no	36	370	298	442	AA	AA	TMUVTA
733	Austin	U-6e	458	-108	no	36	351	279	423	TMLVTA	TMWTA	LTCU
568	Ebbtide	U-3kt	487	-108	no	35	379	309	449	AA	AA	AA
309	Tinderbox	U-9az	547	-108	no	34	440	372	508	LTCU	TMLVTA	LTCU
615	Dutchess	U-7bm	534	-107	no	34	427	359	495	LTCU	LTCU	LTCU
549	Redmud	U-7ab	533	-107	no	34	427	359	495	LTCU	LTCU	LTCU
327	Coffer	U-2de	569	-105	no	58	465	349	581	AA	AA	AA
340	Ildrim	U-2au	514	-104	no	75	410	260	560	TMWTA	AA	TMLVTA
725	Palisade-2	U-4at	490	-100	yes	35	390	320	460	TMLVTA	TMLVTA	TMLVTA
368	Terrine-White	U-9bi #1	556	-99	yes	73	457	311	603	TMLVTA	TMLVTA	OSBCU
359	Planer	U-3eL	476	-98	yes	35	378	308	448	AA	AA	TMUVTA
358	Piccalilli	U-3fc	489	-95	yes	76	394	242	546	LTCU	TMWTA	OSBCU
638	Monterey	U-4aj	495	-95	yes	68	400	264	536	TMLVTA	AA	LTCU
367	Lovage	U-3fe	472	-94	yes	35	378	308	448	AA	AA	TMUVTA
676	Villita	U-3Ld	467	-94	yes	36	372	300	444	AA	AA	TMWTA
645	Manteca	U-4aL	505	-94	yes	68	411	275	547	AA	AA	AA

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151	Crepe	U-2q	498	-94	yes	75	404	254	554	TMLVTA	AA	LTCU
669	Duoro	U-3Lv	474	-93	yes	69	381	243	519	TMUVTA	AA	TMWTA
657	Branco-Herkimer	U-2ew	520	-93	yes	34	427	359	495	TMWTA	AA	TMLVTA
511	Jara	U-3hp	471	-93	yes	35	378	308	448	AA	AA	AA
686	Roquefort	U-4as	508	-92	yes	68	415	279	551	TMLVTA	TMLVTA	LCA3
442	Pedernal	U-3hg	470	-91	yes	35	379	309	449	TMLVTA	TMWTA	LTCU
703	Midland	U-7by	577	-91	yes	65	487	357	617	OSBCU	LTCU	OSBCU
377	Cumarin	U-3gz	498	-90	yes	75	408	258	558	LTCU	TMWTA	OSBCU
570	Bobstay	U-3jb	471	-90	yes	35	381	311	451	TMWTA	AA	TMLVTA
498	Elida	U-3hy	471	-90	yes	35	381	311	451	AA	AA	AA
413	Abeytas	U-3gx	481	-87	yes	76	393	241	545	TMLVTA	AA	OSBCU
726	Palisade-3	U-4at	490	-87	yes	35	404	334	474	TMLVTA	TMLVTA	TMLVTA
252	Washer	U-10r	553	-85	yes	34	468	400	536	LTCU	TMLVTA	LTCU
587	Draughts	U-7aL	526	-84	yes	67	442	308	576	OSBCU	TMLVTA	OSBCU
47	Merrimac	U-3bd	498	-84	yes	75	413	263	563	AA	AA	TMWTA
614	Riola	U-2eq	508	-84	yes	13	424	398	450	AA	AA	AA
45	Haymaker	U-3au	491	-82	yes	52	408	304	512	AA	AA	AA
109	Tuna	U-3de	497	-82	yes	35	414	344	484	AA	AA	AA
631	Akavi	U-2es	576	-82	yes	65	494	364	624	TMLVTA	AA	TMLVTA
510	Fallon	U-2dv	548	-81	yes	73	466	320	612	AA	AA	TMLVTA
277	Shuffle	U-10t	574	-80	yes	72	493	349	637	ATCU	TMLVTA	LCA
171	Scaup	U-3daS	507	-80	yes	34	427	359	495	LTCU	TMLVTA	LTCU
708	Schellbourne	U-2gf	541	-78	yes	66	463	331	595	AA	AA	TMLVTA
184	Charcoal	U-7g	533	-77	yes	73	455	309	601	LTCU	TMWTA	OSBCU
144	Auk	U-7b	529	-76	yes	34	452	384	520	LTCU	LTCU	OSBCU
117	Klickitat	U-10e	568	-76	yes	50	492	392	592	LTCU	TMLVTA	LCA
599	Offshore	U-3ks	472	-76	yes	69	397	259	535	LTCU	TMWTA	LTCU
374	Belen	U-3br	497	-76	yes	74	421	273	569	AA	AA	TMUVTA
244	Mickey	U-7m	573	-74	yes	71	500	358	642	LTCU	LTCU	LCA
727	Tulia	U-4s	471	-73	yes	35	398	328	468	TMUVTA	AA	TMWTA
39	Aardvark	U-3amS	503	-69	yes	43	434	348	520	LTCU	TMWTA	LTCU
600	Nessel	U-2ep	532	-68	yes	66	464	332	596	AA	AA	TMUVTA
138	Canvasback	U-3cp	515	-67	yes	34	448	380	516	LTCU	LTCU	LTCU
723	Ingot	U-2gg	564	-64	yes	65	500	370	630	TMWTA	AA	TMLVTA
250	Stanley	U-10q	547	-64	yes	72	484	340	628	TMLVTA	TMLVTA	LTCU
692	Tajo	U-7bL	582	-63	yes	64	518	390	646	LTCU	LTCU	OSBCU
678	Vaughn	U-3Lr	489	-63	yes	67	426	292	560	TMLVTA	TMUVTA	LTCU
628	Paliza	U-7bd	533	-61	yes	66	472	340	604	LTCU	LTCU	OSBCU
738	Coso-Gray	U-4an	500	-58	yes	34	442	374	510	LTCU	TMLVTA	LTCU

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296	Stoddard	U-2cm-S	522	-55	yes	39	467	390	546	TMLVTA	TMLVTA	LCA3
110	Fore	U-9ao	545	-54	yes	72	491	347	635	TMLVTA	AA	LTCU
428	Harebell	U-2br	572	-54	yes	71	519	377	661	TMLVTA	AA	OSBCU
535	Marsh	U-3kb	480	-53	yes	34	427	359	495	AA	AA	TMUVTA
515	Puye	U-3jL	482	-52	yes	34	430	362	498	AA	AA	AA
598	Burzet	U-4ai	501	-52	yes	66	450	318	582	AA	AA	TMLVTA
335	Torrido	U-7w	566	-52	yes	71	515	373	657	OSBCU	LTCU	LCA
55	Mississippi	U-9ad	546	-51	yes	59	494	376	612	TMLVTA	AA	TMLVTA
691	Panamint	U-2gb	529	-48	yes	33	480	414	546	TMWTA	TMUVTA	TMLVTA
569	Coulommiers	U-2ei	579	-48	yes	64	530	402	658	TMLVTA	TMLVTA	OSBCU
593	Kloster	U-2eo	584	-48	yes	64	536	408	664	TMLVTA	AA	TMLVTA
597	Fajy	U-2fc	584	-47	yes	64	536	408	664	AA	AA	LTCU
629	Tilci	U-4ak	492	-47	yes	67	445	311	579	AA	AA	LTCU
123	Turf	U-10c	553	-47	yes	71	506	364	648	TMLVTA	AA	LTCU
661	Romano	U-2ex	561	-46	yes	64	515	387	643	TMUVTA	AA	LTCU
321	Vise	U-3ej	498	-44	yes	73	454	308	600	TMLVTA	AA	LTCU
280	Clarksmobile	U-2as	515	-42	yes	72	473	329	617	TMLVTA	AA	LTCU
740	Floydada	U-7cb	545	-42	yes	33	503	437	569	OSBCU	LTCU	OSBCU
231	Bourbon	U-7n	601	-41	yes	69	560	422	698	LCA	LTCU	LCA
397	Morrones	U-3ei	518	-35	yes	72	483	339	627	LTCU	TMLVTA	OSBCU
167	Kestrel	U-3dd	481	-34	yes	34	447	379	515	AA	AA	TMLVTA
255	Yard	U-10af	555	-34	yes	71	521	379	663	TMLVTA	AA	LTCU
339	Hutch	U-2df	581	-33	yes	70	548	408	688	AA	AA	TMLVTA
705	Borate	U-2ge	573	-30	yes	63	543	417	669	AA	AA	TMLVTA
567	Scupper	U-3hj	478	-29	yes	34	450	382	518	AA	AA	TMUVTA
562	Strake	U-7ae	546	-29	yes	64	518	390	646	LTCU	LTCU	OSBCU
742	Bristol	U-4av	482	-25	yes	34	457	389	525	LTCU	TMLVTA	LTCU
427	Laguna	U-3fd	480	-25	yes	73	455	309	601	TMWTA	AA	LTCU
739	Coso-Silver	U-4an	500	-24	yes	34	475	407	543	LTCU	LTCU	LTCU
202	Lime	U-7j	585	-23	yes	32	561	497	625	OSBCU	OSBCU	OSBCU
665	Mundo	U-7bo	586	-20	yes	63	566	440	692	OSBCU	LTCU	LCA
483	Angus	U-3jg	472	-20	yes	34	453	385	521	AA	AA	TMUVTA
674	Breton	U-4ar	503	-20	yes	65	483	353	613	TMLVTA	AA	OSBCU
178	Bronze	U-7f	548	-17	yes	70	531	391	671	LTCU	TMLVTA	OSBCU
720	Texarkana	U-7ca	519	-15	yes	65	504	374	634	OSBCU	LTCU	OSBCU
189	Buff	U-3dh	515	-14	yes	71	500	358	642	LTCU	TMLVTA	LTCU
166	Cup	U-9cb	554	-13	yes	70	541	401	681	LTCU	TMLVTA	LCA
714	Bullfrog	U-4au	500	-11	yes	65	489	359	619	TMWTA	AA	TMLVTA
741	Lubbock	U-3mt	468	-11	yes	66	457	325	589	LTCU	TMWTA	LTCU

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731	Metropolis	U-2gh	479	-10	yes	66	469	337	601	TMLVTA	TMUVTA	LTCU
375	Grape B	U-7v	563	-8	yes	69	554	416	692	LTCU	LTCU	ATCU
545	Banon	U-2dz	544	-7	yes	64	537	409	665	AA	AA	TMLVTA
215	Puce	U-3bs	493	-7	yes	33	486	420	552	AA	AA	TMWTA
480	Miera	U-7ad	573	-4	yes	69	568	430	706	OSBCU	LTCU	ATCU
531	Obar	U-7ag	573	-4	yes	69	569	431	707	OSBCU	LTCU	OSBCU
192	Lampblack	U-7i	560	2	yes	69	561	423	699	OSBCU	OSBCU	LCA
589	Quargel	U-2fb	539	3	yes	63	542	416	668	TMLVTA	AA	TMLVTA
331	Thistle	U-7t	556	5	yes	69	561	423	699	OSBCU	LTCU	OSBCU
221	Daiquiri	U-7o	550	11	yes	32	561	497	625	LTCU	LTCU	LTCU
366	Grape A	U-7s	539	12	yes	70	551	411	691	OSBCU	LTCU	LCA
459	Monero	U-3jq	522	15	yes	32	537	473	601	OSBCU	LTCU	OSBCU
386	Shaper	U-7r	545	16	yes	69	561	423	699	OSBCU	OSBCU	LCA
630	Rousanne	U-4p	499	19	yes	64	517	389	645	LTCU	LTCU	LTCU
490	Potrillo	U-7af	548	19	yes	69	567	429	705	OSBCU	LTCU	ATCU
518	Stanyan	U-2aw	554	19	yes	69	573	435	711	TMWTA	AA	LTCU
330	Blenton	U-7p	536	22	yes	69	558	420	696	LTCU	LTCU	ATCU
608	Pyramid	U-7be	557	22	yes	62	579	455	703	OSBCU	LTCU	OSBCU
210	Piranha	U-7e	526	22	yes	70	549	409	689	LTCU	TMLVTA	OSBCU
694	Aleman	U-3kz	475	28	yes	33	503	437	569	TMLVTA	TMWTA	LTCU
436	Algodones	U-3jn	497	31	yes	70	528	388	668	TMUVTA	AA	TMWTA
398	Flask-Green	U-2az #1	497	32	yes	57	529	415	643	TMUVTA	TMUVTA	TMWTA
529	Cabrillo	U-2dr	566	34	yes	68	600	464	736	AA	AA	TMLVTA
429	Miniata	U-2bu	494	35	yes	52	529	425	633	LTCU	LTCU	LTCU
409	Tijeras	U-7y	523	37	yes	69	561	423	699	OSBCU	LTCU	OSBCU
294	Noggin	U-9bx	543	38	yes	69	582	444	720	TMLVTA	TMWTA	LTCU
486	Starwort	U-2bs	525	39	yes	53	564	458	670	LTCU	TMWTA	LTCU
658	Techado	U-4o	493	40	yes	64	532	404	660	LTCU	LTCU	OSBCU
306	Crew-3rd	U-2db	561	41	yes	32	603	539	667	TMLVTA	AA	TMLVTA
558	Bulkhead	U-7am	551	43	yes	62	594	470	718	OSBCU	LTCU	ATCU
468	Oscuro	U-7z	513	47	yes	69	560	422	698	LTCU	TMWTA	LTCU
648	Turquoise	U-7bu	480	53	yes	64	533	405	661	LTCU	TMLVTA	LTCU
351	Calabash	U-2av	569	55	yes	55	625	515	735	LTCU	TMLVTA	LCA
516	Portmanteau	U-2ax	600	55	yes	67	655	521	789	TMLVTA	AA	OSBCU
214	Tan	U-7k	499	62	yes	69	561	423	699	TMLVTA	TMUVTA	LTCU
21	Hard Hat	U-15a	222	66	yes	25	287	237	337	MGCU	MGCU	MGCU
559	Crewline	U-7ap	498	66	yes	63	564	438	690	LTCU	LTCU	OSBCU
643	Borrego	U-7br	493	70	yes	63	563	437	689	LTCU	LTCU	ATCU
584	Lowball	U-7av	490	75	yes	63	565	439	691	LTCU	LTCU	OSBCU

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688	Kinibito	U-3me	496	84	yes	62	579	455	703	LTCU	TMLVTA	LTCU
636	Bouschet	U-3La	479	85	yes	63	564	438	690	LTCU	LTCU	LTCU
552	Rudder	U-7ajS	544	94	yes	61	639	517	761	OSBCU	LTCU	OSBCU
592	Quinella	U-4L	484	95	yes	62	579	455	703	LTCU	TMLVTA	LTCU
573	Farallones	U-2fa	570	97	yes	60	667	547	787	AA	AA	TMLVTA
680	Hermosa	U-7bs	541	97	yes	61	638	516	760	LTCU	LTCU	ATCU
532	Mizzen	U-7ah	536	101	yes	67	637	503	771	LTCU	LTCU	ATCU
639	Atrisco	U-7bp	538	102	yes	59	640	522	758	OSBCU	LTCU	ATCU
695	Gascon	U-4t	490	103	yes	62	593	469	717	LTCU	LTCU	OSBCU
617	Baseball	U-7ba	458	105	yes	63	564	438	690	LTCU	LTCU	ATCU
668	Caprock	U-4q	493	107	yes	62	600	476	724	LTCU	LTCU	OSBCU
539	Esrom	U-7ak	548	107	yes	67	655	521	789	LTCU	LTCU	OSBCU
423	Carpetbag	U-2dg	552	109	yes	69	661	523	799	TMLVTA	AA	TMLVTA
188	Corduroy	U-10k	568	111	yes	66	679	547	811	OSBCU	OSBCU	LCA
477	Flax-Source	U-2dj	577	111	yes	30	688	628	748	TMLVTA	AA	TMLVTA
689	Glencoe	U-4i	493	117	yes	36	610	538	682	OSBCU	LTCU	OSBCU
576	Reblochon	U-2en	534	124	yes	60	658	538	778	LTCU	TMWTA	LTCU
512	Escabosa	U-7ac	513	125	yes	67	639	505	773	LTCU	LTCU	OSBCU
540	Keelson	U-7ai	508	131	yes	67	639	505	773	LTCU	LTCU	OSBCU
263	Cobbler	U-7u	531	136	yes	31	667	605	729	LTCU	LTCU	OSBCU
270	Knox	U-2at	504	141	yes	67	645	511	779	LTCU	LTCU	OSBCU
544	Billet	U-7an	487	150	yes	61	636	514	758	LTCU	LTCU	OSBCU
588	Rummy	U-7au	489	151	yes	61	640	518	762	LTCU	LTCU	LTCU
704	Tahoka	U-3mf	487	151	yes	61	639	517	761	LTCU	LTCU	OSBCU
503	Latir	U-4d	486	155	yes	67	641	507	775	LTCU	LTCU	OSBCU
578	Iceberg	U-4g	485	155	yes	61	640	518	762	LTCU	LTCU	OSBCU
633	Jornada	U-4j	477	162	yes	59	639	521	757	LTCU	LTCU	LTCU
715	Dalhart	U-4u	477	162	yes	61	640	518	762	LTCU	LTCU	OSBCU
663	Tortugas	U-3gg	474	165	yes	61	639	517	761	LTCU	LTCU	OSBCU
601	Hearts	U-4n	473	167	yes	60	640	520	760	LTCU	LTCU	LTCU
581	Transom	U-4f	472	168	yes	0	640	640	640	LTCU	LTCU	LTCU
557	Marsilly	U-2eL	520	169	yes	60	689	569	809	LTCU	TMWTA	LTCU
538	Chiberta	U-2ek	540	176	yes	65	716	586	846	LTCU	LTCU	OSBCU
258	Zaza	U-4c	488	179	yes	66	667	535	799	LTCU	LTCU	OSBCU
211	Dumont	U-2t	486	185	yes	66	671	539	803	LTCU	TMWTA	OSBCU
234	Agile	U-2v	543	190	yes	65	733	603	863	TMLVTA	TMWTA	LTCU
245	Commodore	U-2am	549	196	yes	69	745	607	883	LTCU	TMLVTA	OSBCU
97	Bilby	U-3cn	509	205	yes	70	714	574	854	OSBCU	LTCU	ATCU
259	Lanpher	U-2x	498	217	yes	65	715	585	845	LTCU	TMLVTA	OSBCU

Appendix B

YFDB Identifier	Detonation Name[a]	Hole Name[a]	Water Level (WL) Depth[b] (m)	WP minus WL (m)	Saturated Test?	Calculated Cavity Radius (Rc)[c] (m)	WP Depth[d] (m)	WP-2Rc (m)	WP+2Rc (m)	WP HSU[e]	WP-2Rc HSU[e]	WP+ 2Rc HSU[e]
566	Scantling	U-4h	482	219	yes	60	701	581	821	OSBCU	LTCU	OSBCU
571	Sandreef	U-7aq	479	222	yes	60	701	581	821	LTCU	LTCU	LTCU
528	Topgallant	U-4e	483	230	yes	65	713	583	843	LTCU	LTCU	OSBCU
164	Wagtail	U-3an	492	258	yes	64	750	622	878	LTCU	TMWTA	LTCU
213	Pile Driver	U-15.01	185	277	yes	49	463	365	561	MGCU	MGCU	MGCU
542	Strait	U-4a	484	298	yes	87	782	608	956	OSBCU	LTCU	LCA

[a]DOE/NV--209-Rev 15, as described in this report
[b]Derived from the Yucca Flat EarthVision® hydrostratigraphic model
[c]Calculated cavity radius from [70.2 * Max Yield$^{1/3}$ (kt)] / [overburden density (Mg/m^3) * WP depth (m)]$^{1/4}$, using yield from USDOE, 2000b
[d]LLNL Containment Data Base
[e]HSU information is derived from various data bases and/or the EarthVision® hydrostratigraphic model
[f]DOE/NV--209 Rev 15 states yield for Pod-A, Pod-B, Pod-C, and Pod-D as 16.7 kt (Total). This yield was simply divided by 4 and the result applied to each detonation.

Appendix C

Selected information for unsaturated underground nuclear detonations in shafts and tunnels in the Yucca Flat /Climax Mine CAU, sorted by Hydrostratigraphic Unit at the Water Table.

DETONATIONS WITH WORKING POINT ABOVE THE "SATURATED ZONE"

YFDB Identifier	Detonation Name[a]	Hole Name[a]	Water Level (WL) Depth[b] (m)	WP minus WL (m)	Saturated Test?	Calculated Cavity Radius (Rc)[c] (m)	WP Depth[d] (m)	WP-2Rc (m)	WP+2Rc (m)	WP HSU[e]	WP-2Rc HSU[e]	WP+ 2Rc HSU[e]	HSU at Water Table[e]	Distance WP to WL, in Rc (m)	Crater Depth[d] (m)	Crater Diameter[d] (m)	Distance WP to Bottom of Crater (m)
6	Luna	U-3m	495	-347	no	2	148	144	152	AA	AA	AA	AA	-173.6			
8	Colfax	U-3k	495	-388	no	3	107	101	113	AA	AA	AA	AA	-129.4			
5	Bernalillo	U-3n	495	-356	no	4	139	131	147	AA	AA	AA	AA	-88.9			
400	Flask-Yellow	U-2az #2	516	-181	no	6	335	323	347	AA	AA	AA	AA	-30.2			
20	Armadillo	U-3ar	492	-252	no	28	240	184	296	AA	AA	AA	AA	-9.0	11.2	135.9	228.4
17	Agouti	U-3ao	494	-233	no	27	261	207	315	AA	AA	AA	AA	-8.6	12.9	137.8	248.0
11	Boomer	U-3aa	495	-394	no	49	101	3	199	AA	AA	AA	AA	-8.0			
57	Wolverine	U-3av	494	-421	no	53	73	-33	179	AA	AA	AA	AA	-7.9			
10	Shrew	U-3ac	494	-396	no	50	98	-2	198	AA	AA	AA	AA	-7.9			
16	Stoat	U-3ap	493	-190	no	24	302	254	350	AA	AA	AA	AA	-7.9	2.2	115.8	300.2
85	Tejon	U-3cg	494	-419	no	53	75	-31	181	AA	AA	AA	AA	-7.9			
155	Hoopoe	U-3cf	494	-424	no	54	70	-38	178	AA	AA	AA	AA	-7.8			
197	Cinnamon	U-3dm	487	-367	no	47	120	26	214	AA	AA	AA	AA	-7.8			
27	Ermine	U-3ab	495	-422	no	54	73	-35	181	AA	AA	AA	AA	-7.8			
72	Chipmunk	U-3ay	495	-435	no	56	59	-53	171	AA	AA	AA	AA	-7.8			
89	Hutia	U-3bc	492	-357	no	46	135	43	227	AA	AA	AA	AA	-7.8	6.7	91.4	128.0
31	Chinchilla II	U-3as	494	-357	no	46	137	45	229	AA	AA	AA	AA	-7.8	7.3	79.2	129.3
25	Platypus	U-3ad	494	-436	no	57	58	-56	172	AA	AA	AA	AA	-7.7			
1	Pascal-A	U-3j	496	-344	no	45	152	62	242	AA	AA	AA	AA	-7.6			
2	Pascal-B	U-3d	495	-342	no	45	152	62	242	AA	AA	AA	AA	-7.6			
42	Raccoon	U-3ajS	493	-328	no	44	164	76	252	AA	AA	AA	AA	-7.5	7.9	91.4	156.4
664	Agrini	U-2ev	584	-264	no	37	320	246	394	AA	AA	AA	AA	-7.1	68.6	13.0	251.4
687	Abo	U-3mc	495	-299	no	42	196	112	280	AA	AA	AA	AA	-7.1			
196	Plaid II	U-2r	546	-277	no	39	269	191	347	AA	AA	AA	AA	-7.1	8.1	79.2	260.4
198	Finfoot	U-3du	488	-292	no	42	196	112	280	AA	AA	AA	AA	-7.0	17.6	124.4	178.1
730	Whiteface-B	U-3Lp	481	-299	no	43	183	97	269	AA	AA	AA	AA	-6.9			
729	Whiteface-A	U-3Lp	481	-284	no	42	197	113	281	AA	AA	AA	AA	-6.8			
260	Cognac	U-3fm	495	-255	no	40	240	160	320	AA	AA	AA	AA	-6.4			
29	Hognose	U-3ai	492	-252	no	40	240	160	320	AA	AA	AA	AA	-6.3	20.3	147.5	219.9
303	File	U-3gb	479	-250	no	40	229	149	309	AA	AA	AA	AA	-6.2	14.0	136.6	214.9
344	Pliers	U-3gn	481	-242	no	40	239	159	319	AA	AA	AA	AA	-6.1	14.7	122.5	224.3
242	Chocolate	U-3es	480	-239	no	40	240	160	320	AA	AA	AA	AA	-6.0	10.1	121.9	230.4
208	Cyclamen	U-3cx	496	-191	no	32	305	241	369	AA	AA	AA	AA	-6.0	16.6	83.5	288.5
44	Daman I	U-3be	491	-231	no	39	260	182	338	AA	AA	AA	AA	-5.9	28.1	170.1	232.2
43	Packrat	U-3aw	492	-230	no	39	262	184	340	AA	AA	AA	AA	-5.9	13.5	161.5	248.6
550	Asiago	U-2ar	545	-215	no	37	330	256	404	AA	AA	AA	AA	-5.8	13.0	133.7	317.1
107	Sardine	U-3ch	489	-226	no	39	262	184	340	AA	AA	AA	AA	-5.8	23.8	149.4	238.3
134	Cormorant	U-3df	478	-206	no	39	272	194	350	AA	AA	AA	AA	-5.3			
736	Ledoux	U-1a.01	479	-188	no	38	291	215	367	AA	AA	AA	AA	-4.9			
373	Ajo	U-3gd	486	-182	no	37	304	230	378	AA	AA	AA	AA	-4.9	23.3	167.0	280.9
261	Sazerac	U-3fa	485	-183	no	38	301	225	377	AA	AA	AA	AA	-4.8	14.7	160.0	286.7
326	Barsac	U-3gc	480	-176	no	37	304	230	378	AA	AA	AA	AA	-4.8	22.6	162.2	281.6
447	Hospah	U-3je	482	-180	no	38	302	226	378	AA	AA	AA	AA	-4.7			
582	Jackpots	U-3kj	479	-175	no	37	304	230	378	AA	AA	AA	AA	-4.7			
26	Pampas	U-3aL	490	-127	no	28	363	307	419	AA	AA	AA	AA	-4.5	12.0	189.0	351.0

Appendix C

YFDB Identifier	Detonation Name[a]	Hole Name[a]	Water Level (WL) Depth[b] (m)	WP minus WL (m)	Saturated Test?	Calculated Cavity Radius (Rc)[c] (m)	WP Depth[d] (m)	WP-2Rc (m)	WP+2Rc (m)	WP HSU[e]	WP-2Rc HSU[e]	WP+ 2Rc HSU[e]	HSU at Water Table[e]	Distance WP to WL, in Rc (m)	Crater Depth[d] (m)	Crater Diameter[d] (m)	Distance WP to Bottom of Crater (m)
336	Tapper	U-3go	475	-172	no	38	303	227	379	AA	AA	AA	AA	-4.5	29.1	158.5	273.9
517	Pratt	U-3hq	476	-162	no	37	314	240	388	AA	AA	AA	AA	-4.4	16.1	175.6	297.8
611	Huron King	U-3ky	481	-161	no	37	320	246	394	AA	AA	AA	AA	-4.4	27.1	143.9	292.9
179	Mauve	U-3dp	479	-158	no	37	321	247	395	AA	AA	AA	AA	-4.3	23.5	160.3	297.5
554	Oarlock	U-3km	476	-158	no	37	318	244	392	AA	AA	AA	AA	-4.3	19.8	164.3	297.8
253	Bordeaux	U-3dr	477	-145	no	37	332	258	406	AA	AA	AA	AA	-3.9	24.1	159.1	307.8
476	Flax-Backup	U-2dj	577	-132	no	34	445	377	513	AA	AA	AA	AA	-3.9	28.0	178.0	417.0
553	Cove	U-3ki	474	-139	no	37	335	261	409	AA	AA	AA	AA	-3.8	10.4	131.1	324.3
610	Flora	U-3Lg	472	-137	no	37	335	261	409	AA	AA	AA	AA	-3.7			
18	Dormouse	U-3aq	493	-130	no	36	363	291	435	AA	AA	AA	AA	-3.6	4.4	173.7	358.6
618	Clairette	U-3kr	475	-122	no	36	354	282	426	AA	AA	AA	AA	-3.4			
594	Memory	U-3kq	485	-120	no	36	365	293	437	AA	AA	AA	AA	-3.3	10.7	243.8	354.1
308	Knife B	U-3dz	482	-119	no	36	363	291	435	AA	AA	AA	AA	-3.3	1.4	125.6	361.6
644	Seyval	U-3Lm	481	-115	no	36	366	294	438	AA	AA	AA	AA	-3.2	7.9	180.1	358.2
568	Ebbtide	U-3kt	487	-108	no	35	379	309	449	AA	AA	AA	AA	-3.1	11.3	127.4	368.2
607	Liptauer	U-2eh	585	-168	no	68	417	281	553	AA	AA	AA	AA	-2.5	20.9	203.2	396.1
478	Flax-Test	U-2dj	577	-141	no	74	436	288	584	AA	AA	AA	AA	-1.9	28.0	178.0	407.9
327	Coffer	U-2de	569	-105	no	58	465	349	581	AA	AA	AA	AA	-1.8	39.0	148.1	425.8
491	Portulaca	U-2bv	591	-125	no	73	466	320	612	AA	AA	AA	AA	-1.7	34.5	183.5	431.2
9	San Juan	U-3p	495	-424	no	0	71	71	71	AA	AA	AA	AA	no cavity			
96	Ahtanum	U-2L	604	-377	no	40	226	146	306	AA	AA	AA	ATCU	-9.4	10.1	36.6	216.1
285	Tub-C	U-10aj F	577	-388	no	42	189	105	273	AA	AA	TMLVTA	ATCU	-9.2			
709	Laredo	U-3mh	515	-163	no	71	351	209	493	LTCU	LTCU	OSBCU	ATCU	-2.3	7.6	33.5	343.8
394	Cornice-Green	U-10ap #3	580	-136	no	73	443	297	589	LTCU	TMLVTA	LCA	ATCU	-1.9	46.0	242.8	397.5
662	Gorbea	U-2cq	521	-133	no	69	388	250	526	TMLVTA	TMLVTA	ATCU	ATCU	-1.9	6.0	16.8	382.0
161	Alpaca	U-2a	604	-379	no	10	225	205	245	AA	AA	AA	LCA	-37.9			
357	Scuttle	U-2bh	602	-437	no	19	165	127	203	AA	AA	AA	LCA	-23.0	13.4	21.8	151.2
224	Simms	U-10w	573	-374	no	20	199	159	239	AA	AA	AA	LCA	-18.7	4.6	57.9	194.1
328	Gourd-Amber	U-2bf	606	-425	no	43	181	95	267	AA	AA	AA	LCA	-9.9	4.0	38.1	177.4
292	Imp	U-2bj	602	-423	no	43	179	93	265	AA	AA	AA	LCA	-9.8	6.1	4.6	172.5
61	St. Lawrence	U-2b	599	-433	no	44	166	78	254	AA	AA	AA	LCA	-9.8			
324	Chatty	U-2bn	601	-406	no	42	195	111	279	AA	AA	AA	LCA	-9.7	1.7	8.1	193.1
337	Bowl-1	U-2bo #1	603	-405	no	42	198	114	282	AA	AA	AA	LCA	-9.6	6.1	67.1	192.0
132	Dub	U-10a	575	-316	no	33	259	193	325	AA	AA	AA	LCA	-9.6	27.4	105.8	231.6
187	Kermet	U-2c	594	-398	no	42	196	112	280	AA	AA	AA	LCA	-9.5	9.0	29.3	187.3
497	Seafoam	U-2ea	595	-397	no	42	198	114	282	AA	AA	AA	LCA	-9.5			
346	Kyack-B	U-2bq #2	582	-396	no	42	186	102	270	AA	AA	AA	LCA	-9.4	9.1	73.1	176.8
227	Vigil	U-10ad	572	-481	no	51	91	-11	194	AA	AA	AA	LCA	-9.4			
698	Hazebrook-Emerald (Green)	U-10bh	571	-385	no	42	186	102	270	AA	AA	AA	LCA	-9.2			
555	Dofino	U-10ba	575	-392	no	43	183	97	269	AA	AA	AA	LCA	-9.1			
504	Hulsea	U-2bx	577	-382	no	42	195	111	279	AA	AA	AA	LCA	-9.1			
219	Rovena	U-10s	572	-379	no	42	194	110	278	AA	AA	AA	LCA	-9.0	2.4	35.4	191.1
524	Portola	U-10bb	575	-377	no	42	198	114	282	AA	AA	AA	LCA	-9.0			
452	Sappho	U-2dh #2	552	-354	no	42	198	114	282	AA	AA	AA	LCA	-8.4			
482	Natoma	U-10aw	574	-330	no	40	244	164	324	AA	AA	AA	LCA	-8.2			
711	Rhyolite	U-2ey	600	-393	no	81	207	45	369	AA	AA	LCA	LCA	-4.8			

Appendix C

YFDB Identifier	Detonation Name[a]	Hole Name[a]	Water Level (WL) Depth[b] (m)	WP minus WL (m)	Saturated Test?	Calculated Cavity Radius (Rc)[c] (m)	WP Depth[d] (m)	WP-2Rc (m)	WP+2Rc (m)	WP HSU[e]	WP-2Rc HSU[e]	WP+ 2Rc HSU[e]	HSU at Water Table[e]	Distance WP to WL, in Rc (m)	Crater Depth[d] (m)	Crater Diameter[d] (m)	Distance WP to Bottom of Crater (m)
710	Nightingale	U-2ey	600	-362	no	78	238	82	394	AA	AA	LCA	LCA	-4.6			
291	Tanya	U-2dt	557	-176	no	76	381	229	533	AA	AA	LCA	LCA	-2.3			
363	Tun-B	U-10am #2	613	-419	no	42	194	110	278	AA	AA	LTCU	LCA	-10.0	4.9	39.6	189.0
697	Hazebrook-Checkerberry (Red)	U-10bh	571	-345	no	40	226	146	306	AA	AA	LTCU	LCA	-8.6			
696	Hazebrook-Apricot (Orange)	U-10bh	571	-308	no	39	262	184	340	AA	AA	LTCU	LCA	-7.9			
444	Lagoon	U-10ar	575	-270	no	37	305	231	379	AA	AA	OSBCU	LCA	-7.3	23.2	60.0	281.6
257	Marvel	U-10dS #1	580	-404	no	21	176	134	218	AA	AA	TMLVTA	LCA	-19.3	9.1	43.9	166.8
362	Tun-A	U-10am #1	611	-412	no	42	200	116	284	AA	AA	TMLVTA	LCA	-9.8	12.2	14.6	187.4
279	Crock	U-10ak	583	-401	no	43	182	96	268	AA	AA	TMLVTA	LCA	-9.3	8.2	99.4	173.5
254	Lexington	U-2bm	599	-373	no	40	226	146	306	AA	AA	TMLVTA	LCA	-9.3	7.9	13.4	218.6
287	Tub-F	U-10aj A	575	-386	no	42	189	105	273	AA	AA	TMLVTA	LCA	-9.2			
341	Spider-A	U-2bp #1	582	-369	no	41	213	131	295	AA	AA	TMLVTA	LCA	-9.0			
501	Pinedrops-Sloat	U-10as	576	-362	no	41	213	131	295	AA	AA	TMLVTA	LCA	-8.8			
342	Spider-B	U-2bp #2	581	-353	no	40	228	148	308	AA	AA	TMLVTA	LCA	-8.8	12.2	9.1	215.5
222	Newark	U-10u	573	-344	no	40	229	149	309	AA	AA	TMLVTA	LCA	-8.6	3.0	80.5	225.6
525	Portola-Larkin	U-10bb	575	-301	no	38	275	199	351	AA	AA	TMLVTA	LCA	-7.9			
556	Dofino-Lawton	U-10ba	575	-292	no	38	282	206	358	AA	AA	TMLVTA	LCA	-7.7			
457	Kara	U-2dh #3	554	-294	no	39	259	181	337	AA	AA	TMLVTA	LCA	-7.5			
548	Chevre	U-10ay	572	-255	no	37	317	243	391	AA	AA	TMLVTA	LCA	-6.9	3.4	71.9	313.6
216	Kankakee	U-10p	575	-120	no	73	455	309	601	LCA	AA	LCA	LCA	-1.6	26.2	239.6	428.6
150	Handcar	U-10b	598	-195	no	29	403	345	461	LCA	LCA	LCA	LCA	-6.7			
388	Can-Red	U-2dd #4	554	-155	no	75	399	249	549	LTCU	AA	LCA	LCA	-2.1			
621	Aligote	U-7bg	606	-286	no	37	320	246	394	LTCU	LTCU	OSBCU	LCA	-7.7	10.0	261.8	310.0
616	Dauphin	U-9cq	600	-280	no	37	320	246	394	LTCU	LTCU	OSBCU	LCA	-7.6	13.0	143.9	307.0
596	Chess	U-7at	604	-269	no	37	335	261	409	LTCU	LTCU	OSBCU	LCA	-7.3			
463	Tajique	U-7aa	571	-239	no	37	332	258	406	LTCU	LTCU	OSBCU	LCA	-6.5			
247	Switch	U-9bv	572	-270	no	20	302	262	342	LTCU	TMLVTA	ATCU	LCA	-13.5			
433	Nama-Amarylis	U-9 ITS XY-31	568	-295	no	38	273	197	349	LTCU	TMLVTA	LCA	LCA	-7.8			
421	Avens-Cream	U-9 ITS X-29	566	-273	no	38	293	217	369	LTCU	TMLVTA	LCA	LCA	-7.2	20.8	173.7	272.1
133	Bye	U-10i	566	-175	no	76	391	239	543	LTCU	TMLVTA	LCA	LCA	-2.3	19.7	163.4	371.1
728	Muleshoe	U-7bk	606	-362	no	40	244	164	324	LTCU	TMLVTA	LTCU	LCA	-9.0			
649	Armada	U-9cs	590	-325	no	39	265	187	343	LTCU	TMLVTA	LTCU	LCA	-8.3	7.7	145.8	257.2
526	Teleme	U-9cL	594	-289	no	37	305	231	379	LTCU	TMLVTA	LTCU	LCA	-7.8	13.2	174.9	291.9
419	Avens-Andorre	U-9 ITS T-28	555	-176	no	35	379	309	449	LTCU	TMLVTA	LTCU	LCA	-5.0	9.0	186.5	370.5
637	Kesti	U-9cn	606	-318	no	38	288	212	364	LTCU	TMLVTA	OSBCU	LCA	-8.4			
430	Bracken	U-10aq	585	-280	no	37	305	231	379	LTCU	TMLVTA	OSBCU	LCA	-7.6			
537	Leyden	U-9cm	597	-271	no	37	326	252	400	LTCU	TMLVTA	OSBCU	LCA	-7.3	5.6	180.3	320.5
746	Galena-Yellow	U-9cv	563	-273	no	38	290	214	366	LTCU	TMLVTA	OSBCU	LCA	-7.2			
420	Avens-Asamlte	U-9 ITS W-21	557	-249	no	37	308	234	382	LTCU	TMLVTA	OSBCU	LCA	-6.7	7.6	123.1	299.9
622	Niza	U-9cr	560	-219	no	36	341	269	413	LTCU	TMLVTA	OSBCU	LCA	-6.1	6.3	111.2	335.1
130	Duffer	U-10dS	580	-134	no	34	447	379	515	LTCU	TMLVTA	OSBCU	LCA	-3.9			
679	Cottage	U-8j	627	-112	no	64	515	387	643	OSBCU	LTCU	LCA	LCA	-1.7	38.5	273.2	476.6
591	Baccarat	U-7ax	606	-280	no	37	326	252	400	OSBCU	LTCU	OSBCU	LCA	-7.6	2.7	96.3	323.7
332	Aliment	U-3gj	503	-262	no	40	240	160	320	OSBCU	LTCU	OSBCU	LCA	-6.6			
651	Fahada	U-7bh	606	-222	no	35	384	314	454	OSBCU	LTCU	OSBCU	LCA	-6.3	7.6	166.4	376.8
745	Galena-Orange	U-9cv	563	-183	no	35	380	310	450	OSBCU	LTCU	OSBCU	LCA	-5.2			

YFDB Identifier	Detonation Name[a]	Hole Name[a]	Water Level (WL) Depth[b] (m)	WP minus WL (m)	Saturated Test?	Calculated Cavity Radius (Rc)[c] (m)	WP Depth[d] (m)	WP-2Rc (m)	WP+2Rc (m)	WP HSU[e]	WP-2Rc HSU[e]	WP+ 2Rc HSU[e]	HSU at Water Table[e]	Distance WP to WL, in Rc (m)	Crater Depth[d] (m)	Crater Diameter[d] (m)	Distance WP to Bottom of Crater (m)
744	Galena-Green	U-9cv	563	-163	no	35	400	330	470	OSBCU	LTCU	OSBCU	LCA	-4.7			
619	Seco	U-8L	646	-446	no	42	200	116	284	OSBCU	TMLVTA	OSBCU	LCA	-10.6			
606	Norbo	U-8c	639	-368	no	39	271	193	349	OSBCU	TMLVTA	OSBCU	LCA	-9.4	6.1	18.9	264.9
365	Tun-D	U-10am #4	610	-353	no	39	256	178	334	OSBCU	TMLVTA	OSBCU	LCA	-9.1	9.1	78.0	247.2
620	Vide	U-8k	635	-311	no	37	323	249	397	OSBCU	TMLVTA	OSBCU	LCA	-8.4			
395	Cornice-Yellow	U-10ap #1	584	-194	no	76	390	238	542	OSBCU	TMLVTA	OSBCU	LCA	-2.6	34.9	237.3	355.2
403	Piton-C	U-9 ITS AA-25	573	-472	no	49	101	3	199	TMLVTA	AA	LCA	LCA	-9.6			
393	Hod-C (Blue)	U-9 ITS Z-25	570	-469	no	49	101	3	199	TMLVTA	AA	LCA	LCA	-9.6			
408	Scree-Chamois	U-9 ITS Z-24	569	-469	no	49	101	3	199	TMLVTA	AA	LCA	LCA	-9.6			
502	Pinedrops-Tawny	U-10as	576	-294	no	38	282	206	358	TMLVTA	AA	LCA	LCA	-7.7			
500	Pinedrops-Bayou	U-10as	576	-233	no	36	343	271	415	TMLVTA	AA	LCA	LCA	-6.5			
530	Edam	U-2dy	556	-144	no	75	411	261	561	TMLVTA	AA	LCA	LCA	-1.9	17.0	191.7	394.5
364	Tun-C	U-10am #3	608	-414	no	42	194	110	278	TMLVTA	AA	LTCU	LCA	-9.9	7.3	53.6	186.6
625	Islay	U-2er	587	-293	no	38	294	218	370	TMLVTA	AA	LTCU	LCA	-7.7	8.5	101.8	285.6
156	Mudpack	U-10n	602	-450	no	23	152	106	198	TMLVTA	AA	TMLVTA	LCA	-19.6	6.4	77.4	145.4
30	Hoosic	U-9j	557	-370	no	23	187	141	233	TMLVTA	AA	TMLVTA	LCA	-16.1	7.6	91.4	179.5
381	Arabis-Blue	U-9 ITS Z-26	571	-470	no	49	101	3	199	TMLVTA	AA	TMLVTA	LCA	-9.6			
370	Fob-Blue	U-9 ITS Y-27	567	-467	no	49	101	3	199	TMLVTA	AA	TMLVTA	LCA	-9.5			
602	Pera	U-10bd	575	-375	no	42	200	116	284	TMLVTA	AA	TMLVTA	LCA	-8.9	4.9	79.2	195.0
405	Arnica-Yellow	U-2dd #2	554	-244	no	37	309	235	383	TMLVTA	AA	TMLVTA	LCA	-6.6	34.4	137.2	275.0
580	Asco	U-10bc	579	-397	no	43	183	97	269	TMLVTA	TMLVTA	ATCU	LCA	-9.2			
647	Cheedam	U-2et	585	-242	no	36	343	271	415	TMLVTA	TMLVTA	ATCU	LCA	-6.7	10.0	115.8	332.9
473	Canna-Umbrinus	U-9 ITS YZ-26	568	-385	no	43	183	97	269	TMLVTA	TMLVTA	LCA	LCA	-8.9			
407	Scree-Alhambra	U-9 ITS Z-21	568	-375	no	42	192	108	276	TMLVTA	TMLVTA	LCA	LCA	-8.9	5.5	62.2	186.8
472	Canna-Limoges	U-9 ITS YZ-26	568	-354	no	41	213	131	295	TMLVTA	TMLVTA	LCA	LCA	-8.6			
401	Piton-A	U-9 ITS Y-30	568	-332	no	40	237	157	317	TMLVTA	TMLVTA	LCA	LCA	-8.3			
434	Nama-Mephisto	U-9 ITS Z-27	571	-327	no	40	244	164	324	TMLVTA	TMLVTA	LCA	LCA	-8.2			
406	Scree-Acajou	U-9 ITS X-24	563	-314	no	39	249	171	327	TMLVTA	TMLVTA	LCA	LCA	-8.0	2.0	40.1	247.3
382	Arabis-Green	U-9 ITS X-28	565	-306	no	39	259	181	337	TMLVTA	TMLVTA	LCA	LCA	-7.8			
63	Anacostia	U-9i	569	-342	no	26	227	175	280	TMLVTA	TMLVTA	LTCU	LCA	-13.2	18.6	140.2	208.2
683	Cebrero	U-9cw	611	-428	no	43	183	97	269	TMLVTA	TMLVTA	LTCU	LCA	-10.0			
120	Hook	U-9bc	571	-366	no	41	204	122	286	TMLVTA	TMLVTA	LTCU	LCA	-8.9	6.9	89.9	197.3
462	Haplopappus	U-9 ITS W-22	558	-374	no	42	184	100	268	TMLVTA	TMLVTA	LTCU	LCA	-8.9			
732	Bowie	U-3mk	568	-354	no	41	213	131	295	TMLVTA	TMLVTA	LTCU	LCA	-8.6			
402	Piton-B	U-9 ITS X-27	564	-335	no	40	230	150	310	TMLVTA	TMLVTA	LTCU	LCA	-8.4	3.2	53.0	226.6
507	Plomo	U-3ff	522	-373	no	45	149	59	239	TMLVTA	TMLVTA	LTCU	LCA	-8.3			
470	Akbar	U-10ax	588	-321	no	39	267	189	345	TMLVTA	TMLVTA	LTCU	LCA	-8.2	5.3	119.5	261.4
391	Hod-A (Green)	U-9 ITS X-23	562	-321	no	40	241	161	321	TMLVTA	TMLVTA	LTCU	LCA	-8.0	20.7	135.5	220.1
383	Arabis-Red	U-9 ITS V-26	558	-308	no	39	250	172	328	TMLVTA	TMLVTA	LTCU	LCA	-7.9	6.3	94.2	243.6
392	Hod-B (Red)	U-9 ITS X-20	560	-295	no	39	265	187	343	TMLVTA	TMLVTA	LTCU	LCA	-7.6	13.1	168.9	252.1
372	Fob-Red	U-9 ITS V-24	556	-290	no	39	266	188	344	TMLVTA	TMLVTA	LTCU	LCA	-7.4	9.7	143.3	256.1
418	Avens-Alkermes	U-9 ITS U-24	554	-248	no	37	306	232	380	TMLVTA	TMLVTA	LTCU	LCA	-6.7			
575	Campos	U-9cp	564	-244	no	37	320	246	394	TMLVTA	TMLVTA	LTCU	LCA	-6.6	2.4	70.7	317.3
173	Organdy	U-9bo	588	-415	no	43	173	87	259	TMLVTA	TMLVTA	TMLVTA	LCA	-9.6	1.8	61.0	171.3
624	Havarti	U-10bg	578	-378	no	42	200	116	284	TMLVTA	TMLVTA	TMLVTA	LCA	-9.0			
475	Solanum	U-9 ITS W-24.5	561	-360	no	42	201	117	285	TMLVTA	TMLVTA	TMLVTA	LCA	-8.6			

YFDB Identifier	Detonation Name[a]	Hole Name[a]	Water Level (WL) Depth[b] (m)	WP minus WL (m)	Saturated Test?	Calculated Cavity Radius (Rc)[c] (m)	WP Depth[d] (m)	WP-2Rc (m)	WP+2Rc (m)	WP HSU[e]	WP-2Rc HSU[e]	WP+ 2Rc HSU[e]	HSU at Water Table[e]	Distance WP to WL, in Rc (m)	Crater Depth[d] (m)	Crater Diameter[d] (m)	Distance WP to Bottom of Crater (m)
114	Bunker	U-9bb	564	-338	no	40	226	146	306	TMLVTA	TMLVTA	TMLVTA	LCA	-8.4	12.7	128.0	213.8
371	Fob-Green	U-9 ITS V-27	560	-315	no	40	244	164	324	TMLVTA	TMLVTA	TMLVTA	LCA	-7.9	5.0	111.6	239.4
158	Wool	U-9bh	582	-366	no	41	216	134	298	TMLVTA	TMWTA	LTCU	LCA	-8.9	18.1	137.2	198.0
561	Carnelian	U-4af	492	-284	no	41	208	126	290	AA	AA	LCA3	LCA3	-6.9	10.5	64.5	198.0
521	Temescal	U-4ab	445	-183	no	39	263	185	341	AA	AA	LCA3	LCA3	-4.7			
207	Traveler	U-2cd	497	-300	no	42	198	114	282	AA	AA	LTCU	LCA3	-7.1	5.2	57.9	192.3
240	Heilman	U-2cg	531	-379	no	45	153	63	243	AA	AA	TMLVTA	LCA3	-8.4			
577	Karab	U-4ah	525	-194	no	37	331	257	405	LTCU	TMLVTA	ATCU	LCA3	-5.2	7.6	120.9	323.4
519	Trumbull	U-4aa	400	-137	no	39	263	185	341	TMLVTA	AA	LCA3	LCA3	-3.5			
681	Ville	U-4am	520	-229	no	38	291	215	367	TMLVTA	AA	LTCU	LCA3	-6.0	17.3	119.5	273.8
203	Stutz	U-2ca	466	-240	no	40	226	146	306	TMLVTA	AA	LTCU	LCA3	-6.0	25.9	117.7	200.3
356	Pod-D[f]	U-2cj	512	-200	no	23	312	266	358	TMLVTA	TMLVTA	LTCU	LCA3	-5.7	10.2	84.7	302.2
424	Baneberry	U-8d	649	-371	no	30	278	218	338	TMLVTA	AA	TMLVTA	LCA3	-12.4	23.0	142.0	255.0
667	Bellow	U-4ac	418	-211	no	41	207	125	289	TMLVTA	AA	TMLVTA	LCA3	-5.1	16.8	46.3	190.5
212	Discus Thrower	U-8a	661	-324	no	38	337	261	413	TMLVTA	TMLVTA	LCA3	LCA3	-8.5	20.3	200.1	316.8
721	Kawich-Black	U-2cu	551	-120	no	34	431	363	499	TMLVTA	TMLVTA	LCA3	LCA3	-3.5		28.0	431.3
353	Pod-A[f]	U-2ck	540	-274	no	24	267	219	315	TMLVTA	TMLVTA	TMLVTA	LCA3	-7.6			
722	Kawich-Red	U-2cu	551	-181	no	36	370	298	442	TMLVTA	TMLVTA	TMLVTA	LCA3	-5.0		28.0	370.3
632	Caboc	U-2cp	522	-187	no	37	335	261	409	TMLVTA	TMWTA	TMLVTA	LCA3	-5.0	6.7	45.4	328.3
352	Cruet	U-2cn	523	-259	no	32	264	200	328	TMWTA	AA	TMLVTA	LCA3	-8.1	12.5	103.6	251.2
670	Normanna	U-10cb	350	-150	no	42	200	116	284	LTCU	AA	LCCU	LCCU	-3.6	9.0	108.1	190.9
701	Brie	U-10cc	326	-123	no	41	203	121	285	LTCU	AA	LCCU	LCCU	-3.0	10.3	108.3	192.7
655	Jarlsberg	U-10ca	325	-126	no	42	200	116	284	TMLVTA	AA	OSBCU	LCCU	-3.0	7.0	82.9	192.6
174	Petrel	U-3dy	490	-310	no	17	181	147	215	AA	AA	AA	LTCU	-18.2	5.1	88.4	175.6
157	Parrot	U-3dk	486	-305	no	17	180	146	214	AA	AA	AA	LTCU	-17.9	5.5	79.2	174.9
318	Packard	U-2u	575	-328	no	31	247	185	309	AA	AA	AA	LTCU	-10.6	14.9	106.7	232.0
195	Reo	U-10m	577	-369	no	41	208	126	290	AA	AA	AA	LTCU	-9.0			
139	Player	U-9cc	543	-453	no	51	90	-12	192	AA	AA	AA	LTCU	-8.9			
48	Wichita	U-9y	547	-397	no	45	150	60	240	AA	AA	AA	LTCU	-8.8	17.7	103.6	132.6
82	Paisano	U-9w #1	553	-495	no	57	58	-56	172	AA	AA	AA	LTCU	-8.7			
71	Hatchie	U-9e	546	-485	no	56	61	-51	173	AA	AA	AA	LTCU	-8.7			61.0
58	Tioga	U-9f	543	-484	no	56	59	-53	171	AA	AA	AA	LTCU	-8.6			
46	Sacramento	U-9v	527	-378	no	45	149	59	239	AA	AA	AA	LTCU	-8.4	21.3	109.7	127.7
546	Gouda	U-2ef	552	-352	no	42	200	116	284	AA	AA	AA	LTCU	-8.4			
262	Worth	U-10ag	548	-351	no	42	197	113	281	AA	AA	AA	LTCU	-8.4			
492	Silene	U-9ck	543	-345	no	42	198	114	282	AA	AA	AA	LTCU	-8.2			
300	Hula	U-9bu	543	-345	no	42	198	114	282	AA	AA	AA	LTCU	-8.2	0.9	60.5	197.5
314	Tyg-C	U-2dc #3	551	-323	no	40	228	148	308	AA	AA	AA	LTCU	-8.1	7.2	53.0	221.1
119	Pike	U-3cy	501	-387	no	48	115	19	211	AA	AA	AA	LTCU	-8.1	14.1	73.2	100.5
246	Absinthe	U-3ep	492	-373	no	47	119	25	213	AA	AA	AA	LTCU	-7.9			
268	Brush	U-3eq	492	-373	no	47	118	24	212	AA	AA	AA	LTCU	-7.9			
160	Cashmere	U-2ad	550	-318	no	40	232	152	312	AA	AA	AA	LTCU	-7.9	13.8	109.7	218.5
533	Alviso	U-2du	522	-340	no	43	183	97	269	AA	AA	AA	LTCU	-7.9			
469	Delphinium	U-2dp	562	-267	no	34	296	228	364	AA	AA	AA	LTCU	-7.8	15.6	118.1	280.1
534	Futtock	U-3eh	514	-328	no	42	187	103	271	AA	AA	AA	LTCU	-7.8			
313	Tyg-B	U-2dc #5	555	-304	no	39	251	173	329	AA	AA	AA	LTCU	-7.8	28.2	56.1	223.0

Appendix C

YFDB Identifier	Detonation Name[a]	Hole Name[a]	Water Level (WL) Depth[b] (m)	WP minus WL (m)	Saturated Test?	Calculated Cavity Radius (Rc)[c] (m)	WP Depth[d] (m)	WP-2Rc (m)	WP+2Rc (m)	WP HSU[e]	WP-2Rc HSU[e]	WP+ 2Rc HSU[e]	HSU at Water Table[e]	Distance WP to WL, in Rc (m)	Crater Depth[d] (m)	Crater Diameter[d] (m)	Distance WP to Bottom of Crater (m)
113	Solendon	U-3cz	500	-350	no	45	150	60	240	AA	AA	AA	LTCU	-7.8	1.6	36.6	148.7
652	Danablu	U-2eu	607	-287	no	37	320	246	394	AA	AA	AA	LTCU	-7.8	9.8	106.7	310.2
121	Sturgeon	U-3bo	491	-342	no	45	150	60	240	AA	AA	AA	LTCU	-7.6	5.6	71.9	144.1
317	Tyg-F	U-2dc #6	559	-294	no	39	265	187	343	AA	AA	AA	LTCU	-7.5	38.4	57.3	226.5
514	Crestlake-Tansan	U-2dw	560	-288	no	39	272	194	350	AA	AA	AA	LTCU	-7.4	9.1	52.3	262.5
659	Navata	U-3Lb	500	-317	no	43	183	97	269	AA	AA	AA	LTCU	-7.4			
560	Forefoot	U-3kf	500	-307	no	42	194	110	278	AA	AA	AA	LTCU	-7.3			
59	Bandicoot	U-3bj	489	-247	no	34	241	173	309	AA	AA	AA	LTCU	-7.3	37.9	184.7	203.5
129	Bitterling	U-3cu	497	-304	no	42	193	109	277	AA	AA	AA	LTCU	-7.2	7.0	79.2	185.6
90	Mataco	U-3bk	493	-297	no	42	196	112	280	AA	AA	AA	LTCU	-7.1	17.6	92.0	178.1
547	Sprit	U-3hc	486	-302	no	43	183	97	269	AA	AA	AA	LTCU	-7.0			
52	Hyrax	U-3bh	491	-274	no	41	217	135	299	AA	AA	AA	LTCU	-6.7	29.7	155.4	187.0
274	Bevel	U-3fu	498	-258	no	40	241	161	321	AA	AA	AA	LTCU	-6.4			
186	Sepia	U-3en	496	-255	no	40	241	161	321	AA	AA	AA	LTCU	-6.4	11.8	139.0	229.3
440	Frijoles-Petaca	U-3hz	479	-254	no	40	226	146	306	AA	AA	AA	LTCU	-6.3	0.9	24.1	225.0
68	Acushi	U-3bg	492	-231	no	39	261	183	339	AA	AA	AA	LTCU	-5.9	23.7	156.7	237.2
241	Fawn	U-3eo	500	-229	no	39	271	193	349	AA	AA	AA	LTCU	-5.9	15.7	155.4	255.3
100	Grunion	U-3bz	487	-226	no	39	261	183	339	AA	AA	AA	LTCU	-5.8	30.6	146.3	230.6
432	Barranca	U-3he	481	-210	no	39	271	193	349	AA	AA	AA	LTCU	-5.4			
267	Staccato	U-10ah	559	-116	no	73	443	297	589	AA	AA	OSBCU	LTCU	-1.6	16.8	268.2	426.7
101	Tornillo	U-9aq	559	-409	no	12	150	126	174	AA	AA	TMLVTA	LTCU	-34.1	0.6	121.9	149.1
122	Bogey	U-9au	557	-438	no	47	119	25	213	AA	AA	TMLVTA	LTCU	-9.3			
126	Backswing	U-9aw	547	-384	no	44	163	75	251	AA	AA	TMLVTA	LTCU	-8.7	17.5	111.6	145.9
640	Queso	U-10bf	571	-354	no	41	216	134	298	AA	AA	TMLVTA	LTCU	-8.6			
81	Kootanai	U-9w	552	-370	no	43	182	96	268	AA	AA	TMLVTA	LTCU	-8.6	13.6	98.7	168.4
36	Black	U-9p	549	-332	no	41	218	136	300	AA	AA	TMLVTA	LTCU	-8.1	21.9	120.1	195.7
451	Dianthus	U-10at	572	-267	no	37	305	231	379	AA	AA	TMLVTA	LTCU	-7.2	9.9	147.2	294.9
481	Gazook	U-2do	558	-232	no	37	326	252	400	AA	AA	TMLVTA	LTCU	-6.3			
127	Minnow	U-3cv	492	-251	no	40	241	161	321	AA	AA	TMLVTA	LTCU	-6.3	8.4	126.8	233.0
106	Barracuda	U-3cr	495	-231	no	39	263	185	341	AA	AA	TMLVTA	LTCU	-5.9			
83	Gundi Prime	U-3db	498	-226	no	39	272	194	350	AA	AA	TMLVTA	LTCU	-5.8	17.7	161.5	254.2
513	Crestlake-Briar	U-2dw	560	-186	no	36	374	302	446	AA	AA	TMLVTA	LTCU	-5.2	9.1	52.3	364.6
92	Pekan	U-3bw	490	-188	no	38	302	226	378	AA	AA	TMLVTA	LTCU	-4.9	18.5	151.2	283.9
425	Embudo	U-3hd	484	-181	no	38	303	227	379	AA	AA	TMLVTA	LTCU	-4.8	23.8	157.0	279.2
98	Carp	U-3cb	486	-157	no	37	329	255	403	AA	AA	TMLVTA	LTCU	-4.2			
194	Dovekie	U-3cd	483	-150	no	37	333	259	407	AA	AA	TMLVTA	LTCU	-4.0	5.0	141.4	328.1
273	Pommard	U-3ee	501	-292	no	17	209	175	243	AA	AA	TMUVTA	LTCU	-17.2	2.0	88.4	207.1
237	Mushroom	U-3ef	491	-312	no	43	180	94	266	AA	AA	TMUVTA	LTCU	-7.2	8.5	101.8	171.0
136	Trogon	U-3dj	497	-304	no	42	193	109	277	AA	AA	TMUVTA	LTCU	-7.2			
182	Moa	U-3ed	487	-294	no	42	194	110	278	AA	AA	TMUVTA	LTCU	-7.0	9.9	107.3	183.6
159	Tern	U-3dw	495	-284	no	41	211	129	293	AA	AA	TMUVTA	LTCU	-6.9	4.8	94.5	205.8
162	Merlin	U-3ct	497	-201	no	30	296	236	356	AA	AA	TMUVTA	LTCU	-6.7	16.8	155.4	279.5
66	Numbat	U-3bu	494	-262	no	40	232	152	312	AA	AA	TMUVTA	LTCU	-6.6	15.2	170.7	216.8
223	Khaki	U-3et	495	-262	no	40	233	153	313	AA	AA	TMUVTA	LTCU	-6.6			
84	Harkee	U-3bv	492	-251	no	40	241	161	321	AA	AA	TMUVTA	LTCU	-6.3	7.7	115.8	233.7
282	Wembley	U-3ey	485	-247	no	40	238	158	318	AA	AA	TMUVTA	LTCU	-6.2	9.1	139.6	228.9

YFDB Identifier	Detonation Name[a]	Hole Name[a]	Water Level (WL) Depth[b] (m)	WP minus WL (m)	Saturated Test?	Calculated Cavity Radius (Rc)[c] (m)	WP Depth[d] (m)	WP-2Rc (m)	WP+2Rc (m)	WP HSU[e]	WP-2Rc HSU[e]	WP+ 2Rc HSU[e]	HSU at Water Table[e]	Distance WP to WL, in Rc (m)	Crater Depth[d] (m)	Crater Diameter[d] (m)	Distance WP to Bottom of Crater (m)
541	Shallows	U-3jf	481	-237	no	40	245	165	325	AA	AA	TMUVTA	LTCU	-5.9	11.3	137.5	233.5
103	Anchovy	U-3bq	488	-228	no	39	260	182	338	AA	AA	TMUVTA	LTCU	-5.8	21.0	158.5	239.3
439	Frijoles-Guaje	U-3hf	479	-222	no	39	257	179	335	AA	AA	TMUVTA	LTCU	-5.7			
193	Sienna	U-3cj	487	-212	no	38	275	199	351	AA	AA	TMUVTA	LTCU	-5.6	10.4	153.6	264.5
135	Links	U-9bf	566	-445	no	47	120	26	214	AA	AA	TMWTA	LTCU	-9.5			
176	Izzer	U-9bp	565	-402	no	44	164	76	252	AA	AA	TMWTA	LTCU	-9.1	1.0	38.4	162.7
299	Vat	U-9cf	543	-348	no	42	195	111	279	AA	AA	TMWTA	LTCU	-8.3	11.0	106.1	184.1
50	York	U-9z	546	-319	no	40	226	146	306	AA	AA	TMWTA	LTCU	-8.0	24.1	152.4	202.4
488	Cabresto	U-7h	519	-321	no	42	198	114	282	AA	AA	TMWTA	LTCU	-7.6			
333	Ipecac-A	U-3hk-a	472	-348	no	47	124	30	218	AA	AA	TMWTA	LTCU	-7.4			
360	Culantro-A	U-3hi-a	472	-338	no	46	134	42	226	AA	AA	TMWTA	LTCU	-7.3			
226	Cerise	U-3eu	494	-283	no	41	211	129	293	AA	AA	TMWTA	LTCU	-6.9	15.2	137.8	196.0
706	Waco	U-3Lu	461	-278	no	43	183	97	269	AA	AA	TMWTA	LTCU	-6.5			
251	Gibson	U-3ew	479	-238	no	40	241	161	321	AA	AA	TMWTA	LTCU	-6.0	22.3	109.4	218.5
146	Barbel	U-3bx	488	-229	no	39	259	181	337	AA	AA	TMWTA	LTCU	-5.9	15.3	143.9	243.5
77	Gerbil	U-3bp	489	-210	no	38	280	204	356	AA	AA	TMWTA	LTCU	-5.5	14.7	167.6	264.8
615	Dutchess	U-7bm	534	-107	no	34	427	359	495	LTCU	LTCU	LTCU	LTCU	-3.1			
149	Forest	U-7a	562	-175	no	35	387	317	457	LTCU	TMLVTA	LTCU	LTCU	-5.0			
140	Haddock	U-3dL	515	-151	no	36	364	292	436	LTCU	TMLVTA	LTCU	LTCU	-4.2			
343	Horehound	U-3gm	460	-128	no	37	332	258	406	LTCU	TSA	LTCU	LTCU	-3.5			331.9
295	Knife A	U-3fb	483	-151	no	37	332	258	406	TMLVTA	AA	LTCU	LTCU	-4.1	0.4	38.3	331.5
86	Stones	U-9ae	547	-154	no	76	393	241	545	TMLVTA	AA	LTCU	LTCU	-2.0	26.5	259.8	366.7
509	Grove	U-2ds	537	-223	no	37	314	240	388	TMLVTA	AA	TMLVTA	LTCU	-6.0	7.6	58.5	306.6
583	Satz	U-2dq	536	-221	no	37	315	241	389	TMLVTA	AA	TMLVTA	LTCU	-6.0	8.8	69.2	306.1
290	Spud	U-3fy	464	-223	no	40	240	160	320	TMLVTA	AA	TSA	LTCU	-5.6	2.5	118.3	237.7
265	Stilt	U-3fh	497	-164	no	37	333	259	407	TMLVTA	TMLVTA	LTCU	LTCU	-4.4			
289	Sevilla	U-3fk	516	-157	no	36	359	287	431	TMLVTA	TMLVTA	LTCU	LTCU	-4.4			
609	Canfield	U-3kx	504	-153	no	36	351	279	423	TMLVTA	TMLVTA	LTCU	LTCU	-4.3	10.9	221.9	339.6
443	Cathay	U-9ch	552	-174	no	35	378	308	448	TMLVTA	TMLVTA	TMLVTA	LTCU	-5.0	7.6	263.3	370.4
671	Correo	U-3Lw	475	-141	no	37	334	260	408	TMLVTA	TMUVTA	LTCU	LTCU	-3.8	27.4	188.4	306.7
634	Tenaja	U-3Lh	470	-114	no	36	356	284	428	TMLVTA	TMWTA	LTCU	LTCU	-3.2	10.7	193.6	345.6
733	Austin	U-6e	458	-108	no	36	351	279	423	TMLVTA	TMWTA	LTCU	LTCU	-3.0			
116	Mackerel	U-4b	484	-150	no	37	334	260	408	TMLVTA	TMWTA	TMLVTA	LTCU	-4.1	2.2	81.7	331.6
700	Presidio	U-6d	458	-138	no	37	320	246	394	TMLVTA	TMWTA	TSA	LTCU	-3.7			
508	Jib	U-3hb	463	-283	no	43	180	94	266	TMUVTA	AA	TMWTA	LTCU	-6.6			
646	Coalora	U-3Lo	492	-218	no	38	274	198	350	TMUVTA	AA	TMWTA	LTCU	-5.7			
70	Ferret	U-3bf	502	-176	no	37	326	252	400	TMUVTA	AA	TMWTA	LTCU	-4.8			
737	Coso-Bronze	U-4an	500	-166	no	37	333	259	407	TMWTA	AA	LTCU	LTCU	-4.5			
390	Beebalm	U-3fn	503	-112	no	35	390	320	460	TMWTA	AA	LTCU	LTCU	-3.2	0.1	275.5	390.0
185	Elkhart	U-9bs	558	-338	no	41	220	138	302	TMWTA	AA	TMLVTA	LTCU	-8.2	10.6	125.9	209.8
228	Sidecar	U-3ez	489	-249	no	40	240	160	320	TMWTA	AA	TMLVTA	LTCU	-6.2	5.8	148.7	234.4
183	Screamer	U-3dg	478	-176	no	38	302	226	378	TMWTA	AA	TMLVTA	LTCU	-4.6	21.9	154.2	280.2
271	Torch	U-3fj	501	-261	no	40	240	160	320	TMWTA	TMUVTA	TMLVTA	LTCU	-6.5			
654	Sabado	U-3Lc	461	-141	no	37	320	246	394	UTCU	TMWTA	LTCU	LTCU	-3.8	2.4	101.5	317.6
175	Tiny Tot	U-15e	228	-117	no	48	111	15	207	MGCU	MGCU	MGCU	MGCU	-2.4			
205	Fenton	U-2m #1	601	-434	no	18	167	131	203	AA	AA	AA	OSBCU	-24.1	10.4	9.1	156.9

YFDB Identifier	Detonation Name[a]	Hole Name[a]	Water Level (WL) Depth[b] (m)	WP minus WL (m)	Saturated Test?	Calculated Cavity Radius (Rc)[c] (m)	WP Depth[d] (m)	WP-2Rc (m)	WP+2Rc (m)	WP HSU[e]	WP-2Rc HSU[e]	WP+ 2Rc HSU[e]	HSU at Water Table[e]	Distance WP to WL, in Rc (m)	Crater Depth[d] (m)	Crater Diameter[d] (m)	Distance WP to Bottom of Crater (m)
137	Alva	U-2j	602	-436	no	26	166	114	218	AA	AA	AA	OSBCU	-16.8	8.2	76.2	157.9
239	Oakland	U-2bi	601	-435	no	44	166	78	254	AA	AA	AA	OSBCU	-9.9			
99	Narraguagus	U-2f	589	-439	no	45	150	60	240	AA	AA	AA	OSBCU	-9.7			
249	Vito	U-10ab	571	-475	no	50	97	-3	197	AA	AA	AA	OSBCU	-9.5			
506	Potrero	U-2eb	597	-386	no	41	211	129	293	AA	AA	AA	OSBCU	-9.4	10.0	33.5	200.9
345	Kyack-A	U-2bq #1	586	-394	no	42	192	108	276	AA	AA	AA	OSBCU	-9.4	9.1	56.1	182.9
329	Gourd-Brown	U-2bL	600	-373	no	40	227	147	307	AA	AA	AA	OSBCU	-9.3			
338	Bowl-2	U-2bo #2	600	-371	no	40	229	149	309	AA	AA	AA	OSBCU	-9.3	6.1	84.1	222.5
276	Throw	U-2bg	601	-370	no	40	231	151	311	AA	AA	AA	OSBCU	-9.3	43.0	4.6	187.7
493	Polygonum	U-2by	592	-379	no	41	213	131	295	AA	AA	AA	OSBCU	-9.2			
229	Rivet I	U-10aa	567	-415	no	45	152	62	242	AA	AA	AA	OSBCU	-9.2			
80	Cumberland	U-2e	588	-361	no	40	227	147	307	AA	AA	AA	OSBCU	-9.0	18.9	140.2	208.2
325	Valise	U-9by	548	-456	no	51	91	-11	193	AA	AA	AA	OSBCU	-8.9			
551	Sutter	U-2bw	573	-373	no	42	200	116	284	AA	AA	AA	OSBCU	-8.9			
232	Rivet II	U-10z	563	-365	no	42	198	114	282	AA	AA	AA	OSBCU	-8.7	3.0	39.6	194.5
264	Polka	U-10ai	558	-363	no	42	195	111	279	AA	AA	AA	OSBCU	-8.6			
460	Merida	U-2dn	556	-352	no	41	204	122	286	AA	AA	AA	OSBCU	-8.6	5.7	46.4	198.5
404	Arnica-Violet	U-2dd #3	558	-294	no	39	264	186	342	AA	AA	AA	OSBCU	-7.5	13.5	31.2	250.2
236	Rivet III	U-10y	567	-294	no	38	274	198	350	AA	AA	LTCU	OSBCU	-7.7	3.7	140.2	270.0
387	Can-Green	U-2dd #1	554	-279	no	83	274	108	440	AA	AA	LTCU	OSBCU	-3.4	9.0	94.0	265.3
585	Cremino	U-8e	588	-378	no	41	210	128	292	AA	AA	TMLVTA	OSBCU	-9.2			
283	Tub-A	U-10aj C	575	-386	no	42	189	105	273	AA	AA	TMLVTA	OSBCU	-9.2	7.6	121.9	181.4
284	Tub-B	U-10aj B	573	-384	no	42	189	105	273	AA	AA	TMLVTA	OSBCU	-9.2	10.7	106.7	178.3
118	Handicap	U-9ba	554	-410	no	45	144	54	234	AA	AA	TMLVTA	OSBCU	-9.1	2.4	46.3	141.2
35	Dead	U-9k	566	-372	no	42	194	110	278	AA	AA	TMLVTA	OSBCU	-8.9	5.2	94.5	188.3
233	Ward	U-10x	571	-311	no	39	260	182	338	AA	AA	TMLVTA	OSBCU	-8.0	9.1	79.2	250.9
489	Kashan	U-10av	567	-301	no	39	265	187	343	AA	AA	TMLVTA	OSBCU	-7.7	7.4	142.6	257.8
494	Waller	U-2bz	582	-271	no	37	311	237	385	AA	AA	TMLVTA	OSBCU	-7.3			
217	Vulcan	U-2bd	588	-266	no	40	322	242	402	AA	AA	TMLVTA	OSBCU	-6.7	23.5	160.3	298.7
95	Natches	U-9ak #1	554	-495	no	56	59	-53	171	AA	AA	TMWTA	OSBCU	-8.8			
563	Flotost	U-2ao	569	-294	no	38	275	199	351	AA	AA	TMWTA	OSBCU	-7.7	7.0	25.4	268.2
350	Seaweed B	U-3hk-d	474	-356	no	47	119	25	213	AA	AA	TMWTA	OSBCU	-7.6			
347	Seaweed-C	U-3hk-e	473	-355	no	47	119	25	213	AA	AA	TMWTA	OSBCU	-7.5			
348	Seaweed-D	U-3hk-f	472	-353	no	47	119	25	213	AA	AA	TMWTA	OSBCU	-7.5			
349	Seaweed-E	U-3hk-c	474	-350	no	47	124	30	218	AA	AA	TMWTA	OSBCU	-7.4			
334	Ipecac-B	U-3hk-b	473	-349	no	47	124	30	218	AA	AA	TMWTA	OSBCU	-7.4			
361	Culantro-B	U-3hi-b	473	-324	no	45	149	59	239	AA	AA	TMWTA	OSBCU	-7.2			
666	Orkney	U-10be	606	-396	no	41	210	128	292	AA	AA	TUBA	OSBCU	-9.7			
297	Knife C	U-3er	495	-194	no	38	301	225	377	LTCU	AA	LTCU	OSBCU	-5.1	1.8	140.2	299.6
417	Artesia	U-7x	595	-110	no	72	485	341	629	LTCU	LTCU	ATCU	OSBCU	-1.5	30.7	273.7	454.2
549	Redmud	U-7ab	533	-107	no	34	427	359	495	LTCU	LTCU	LTCU	OSBCU	-3.1	1.5	82.9	425.2
143	Courser	U-3do	523	-164	no	0	359	359	359	LTCU	LTCU	LTCU	OSBCU	no cavity			
389	Snubber	U-3ev-2S	551	-207	no	31	344	282	406	LTCU	LTCU	OSBCU	OSBCU	-6.7	3.8	144.5	339.7
672	Dolcetto	U-7bi	568	-203	no	36	365	293	437	LTCU	LTCU	OSBCU	OSBCU	-5.6	4.9	120.1	360.3
685	Ponil	U-7bv	556	-191	no	36	365	293	437	LTCU	LTCU	OSBCU	OSBCU	-5.3	3.2	110.9	361.6
747	Divider	U-3mL	503	-163	no	36	340	268	412	LTCU	LTCU	OSBCU	OSBCU	-4.5			

Appendix C

YFDB Identifier	Detonation Name[a]	Hole Name[a]	Water Level (WL) Depth[b] (m)	WP minus WL (m)	Saturated Test?	Calculated Cavity Radius (Rc)[c] (m)	WP Depth[d] (m)	WP-2Rc (m)	WP+2Rc (m)	WP HSU[e]	WP-2Rc HSU[e]	WP+ 2Rc HSU[e]	HSU at Water Table[e]	Distance WP to WL, in Rc (m)	Crater Depth[d] (m)	Crater Diameter[d] (m)	Distance WP to Bottom of Crater (m)
309	Tinderbox	U-9az	547	-108	no	34	440	372	508	LTCU	TMLVTA	LTCU	OSBCU	-3.2			
719	Kawich A-White	U-8n	540	-171	no	36	369	297	441	LTCU	TMLVTA	OSBCU	OSBCU	-4.8			
376	Labis	U-10an	580	-138	no	37	442	368	516	LTCU	TMLVTA	OSBCU	OSBCU	-3.7	7.6	243.8	434.4
369	Terrine-Yellow	U-9bi #2	572	-154	no	75	418	268	568	LTCU	TMLVTA	OSBCU	OSBCU	-2.1	7.0	121.6	410.6
431	Apodaca	U-3gs	487	-246	no	40	241	161	321	LTCU	TMWTA	LTCU	OSBCU	-6.1			
579	Topmast	U-7ay	576	-118	no	34	458	390	526	OSBCU	LTCU	OSBCU	OSBCU	-3.5			
718	Kawich A-Blue	U-8n	540	-156	no	35	384	314	454	OSBCU	TMLVTA	OSBCU	OSBCU	-4.5			
642	Frisco	U-8m	583	-132	no	66	451	319	583	OSBCU	TMLVTA	OSBCU	OSBCU	-2.0	5.3	139.0	445.8
180	Ticking	U-9bj	582	-372	no	41	210	128	292	TMLVTA	AA	LTCU	OSBCU	-9.1			
131	Fade	U-9be	574	-369	no	41	205	123	287	TMLVTA	AA	LTCU	OSBCU	-9.0	14.4	126.8	190.7
286	Tub-D	U-10aj D	572	-299	no	38	273	197	349	TMLVTA	AA	LTCU	OSBCU	-7.9			
445	Parnassia	U-2bc	592	-261	no	37	331	257	405	TMLVTA	AA	LTCU	OSBCU	-7.1	18.9	154.2	311.8
165	Suede	U-9bk	581	-437	no	45	143	53	233	TMLVTA	AA	TMLVTA	OSBCU	-9.7	0.6	7.6	142.7
163	Seersucker	U-9bm	568	-424	no	45	144	54	234	TMLVTA	AA	TMLVTA	OSBCU	-9.4			
142	Spoon	U-9bd	583	-403	no	43	180	94	266	TMLVTA	AA	TMLVTA	OSBCU	-9.4	1.2	14.3	178.6
148	Garden	U-9aj	568	-418	no	45	150	60	240	TMLVTA	AA	TMLVTA	OSBCU	-9.3			
191	Maxwell	U-9br	578	-395	no	43	183	97	269	TMLVTA	AA	TMLVTA	OSBCU	-9.2			
94	Kohocton	U-9ak	566	-312	no	39	255	177	333	TMLVTA	AA	TMLVTA	OSBCU	-8.0			
320	Biggin	U-9bz	545	-303	no	40	242	162	322	TMLVTA	AA	TMLVTA	OSBCU	-7.6			
435	Baltic	U-9 ITS S-25	547	-135	no	35	412	342	482	TMLVTA	TMLVTA	LTCU	OSBCU	-3.9			
384	Cyathus	U-8b	611	-317	no	29	294	236	352	TMLVTA	TMLVTA	TMLVTA	OSBCU	-10.9	9.1	75.2	284.7
172	Tweed	U-9bn	576	-292	no	38	284	208	360	TMLVTA	TMLVTA	TMLVTA	OSBCU	-7.7	45.1	192.0	239.3
307	Auger	U-3fx	507	-266	no	40	240	160	320	TMLVTA	TMLVTA	TMLVTA	OSBCU	-6.7			
586	Cremino-Caerphilly	U-8e	588	-168	no	35	420	350	490	TMLVTA	TMLVTA	TMLVTA	OSBCU	-4.8			
471	Arsenate	U-9ci	562	-312	no	39	250	172	328	TMLVTA	TMWTA	LTCU	OSBCU	-8.0			
422	Canjilon	U-3fq	522	-219	no	38	302	226	378	TMLVTA	TMWTA	LTCU	OSBCU	-5.8			
111	Oconto	U-9ay	552	-287	no	31	265	203	327	TMLVTA	TMWTA	TMLVTA	OSBCU	-9.3	10.5	137.2	254.1
204	Tomato	U-3ek	489	-262	no	40	226	146	306	TMLVTA	TMWTA	TSA	OSBCU	-6.6	4.3	134.1	221.9
623	Pineau	U-7ao	552	-345	no	41	207	125	289	TMUVTA	AA	TMLVTA	OSBCU	-8.4			
201	Templar	U-9bt	568	-418	no	12	150	126	174	TMWTA	AA	TMLVTA	OSBCU	-34.8	0.9	9.1	149.1
168	Chenille	U-9bg	569	-429	no	45	141	51	231	TMWTA	AA	TMLVTA	OSBCU	-9.5	14.9	95.4	125.9
54	Allegheny	U-9x	564	-353	no	41	211	129	293	TMWTA	AA	TMLVTA	OSBCU	-8.6	3.0	87.8	207.9
23	Codsaw	U-9g	550	-338	no	41	212	130	294	TMWTA	AA	TMLVTA	OSBCU	-8.2	3.4	90.2	208.7
169	Muscovy	U-3dx	482	-302	no	43	180	94	266	TMWTA	AA	TMLVTA	OSBCU	-7.0	2.1	83.5	178.3
396	Manzanas	U-3gr	485	-244	no	40	241	161	321	TSA	TMLVTA	OSBCU	OSBCU	-6.1			
281	Adze	U-3fw	475	-235	no	40	240	160	320	TSA	TMWTA	LTCU	OSBCU	-5.9			
319	Shave	U-3gk	483	-242	no	40	241	161	321	UTCU	TMLVTA	LTCU	OSBCU	-6.1	9.0	135.3	231.8
14	Mad	U-9a	537	-356	no	12	182	158	206	AA	AA	AA	TMLVTA	-29.6			
19	Stillwater	U-9c	537	-356	no	23	181	135	227	AA	AA	AA	TMLVTA	-15.5	12.2	121.9	169.2
128	Ace	U-2n	579	-316	no	21	263	221	305	AA	AA	AA	TMLVTA	-15.1			
108	Eagle	U-9av	541	-376	no	28	165	109	221	AA	AA	AA	TMLVTA	-13.4	18.3	121.9	146.6
40	Eel	U-9m	536	-319	no	25	218	168	268	AA	AA	AA	TMLVTA	-12.8	4.0	76.2	213.6
170	Tee	U-2ab	564	-374	no	30	190	130	250	AA	AA	AA	TMLVTA	-12.5	9.0	117.3	181.2
266	Hupmobile	U-2y	573	-326	no	28	247	191	303	AA	AA	AA	TMLVTA	-11.6	9.8	76.8	237.1
73	Carmel	U-2h	599	-435	no	44	163	75	251	AA	AA	AA	TMLVTA	-9.9	12.0	45.7	151.4
28	Brazos	U-9d	535	-276	no	29	259	201	317	AA	AA	AA	TMLVTA	-9.5	9.4	106.7	249.7

YFDB Identifier	Detonation Name[a]	Hole Name[a]	Water Level (WL) Depth[b] (m)	WP minus WL (m)	Saturated Test?	Calculated Cavity Radius (Rc)[c] (m)	WP Depth[d] (m)	WP-2Rc (m)	WP+2Rc (m)	WP HSU[e]	WP-2Rc HSU[e]	WP+ 2Rc HSU[e]	HSU at Water Table[e]	Distance WP to WL, in Rc (m)	Crater Depth[d] (m)	Crater Diameter[d] (m)	Distance WP to Bottom of Crater (m)
93	Satsop	U-2g	590	-365	no	40	225	145	305	AA	AA	AA	TMLVTA	-9.1	12.2	91.4	212.7
181	Centaur	U-2ak	561	-389	no	43	172	86	258	AA	AA	AA	TMLVTA	-9.0	5.7	26.8	166.2
88	Apshapa	U-9ai	544	-455	no	51	89	-13	191	AA	AA	AA	TMLVTA	-8.9	12.2	4.6	76.8
76	Toyah	U-9ac	538	-408	no	46	131	39	223	AA	AA	AA	TMLVTA	-8.9	1.5	27.4	129.3
112	Club	U-2aa	559	-379	no	43	180	94	266	AA	AA	AA	TMLVTA	-8.8	8.1	39.2	172.3
51	Raritan	U-9u	540	-384	no	44	156	68	244	AA	AA	AA	TMLVTA	-8.7	7.3	68.3	149.1
67	Manatee	U-9af	543	-484	no	56	60	-52	172	AA	AA	AA	TMLVTA	-8.6			
34	Hudson	U-9n	539	-388	no	45	151	61	241	AA	AA	AA	TMLVTA	-8.6	1.8	9.1	149.1
604	Azul	U-2em	556	-351	no	41	205	123	287	AA	AA	AA	TMLVTA	-8.6			
543	Rivoli	U-2eg	559	-359	no	42	200	116	284	AA	AA	AA	TMLVTA	-8.5			
104	Mustang	U-9at	542	-376	no	44	166	78	254	AA	AA	AA	TMLVTA	-8.5	4.0	53.0	161.8
38	Arikaree	U-9r	538	-372	no	44	166	78	254	AA	AA	AA	TMLVTA	-8.4	2.0	54.9	164.4
479	Alumroot	U-9cj	546	-363	no	43	183	97	269	AA	AA	AA	TMLVTA	-8.4			
315	Tyg-D	U-2dc #2	553	-346	no	41	207	125	289	AA	AA	AA	TMLVTA	-8.4	7.6	45.7	199.4
316	Tyg-E	U-2dc #1	551	-353	no	42	198	114	282	AA	AA	AA	TMLVTA	-8.4	8.5	78.0	189.3
243	Effendi	U-2ap	560	-339	no	41	221	139	303	AA	AA	AA	TMLVTA	-8.3	3.7	34.7	217.3
564	Gruyere	U-9cg	545	-337	no	41	207	125	289	AA	AA	AA	TMLVTA	-8.2			
56	Roanoke	U-9q	530	-354	no	43	177	91	263	AA	AA	AA	TMLVTA	-8.2	1.4	24.4	175.4
312	Tyg-A	U-2dc #4	556	-328	no	40	228	148	308	AA	AA	AA	TMLVTA	-8.2	33.5	15.2	194.8
41	White	U-9b	534	-341	no	42	193	109	277	AA	AA	AA	TMLVTA	-8.1	15.5	140.2	177.1
293	Rack	U-9ap	536	-336	no	42	200	116	284	AA	AA	AA	TMLVTA	-8.0	6.1	67.1	193.5
190	Emerson	U-2aL	564	-304	no	39	260	182	338	AA	AA	AA	TMLVTA	-7.8	7.3	75.6	252.7
64	Taunton	U-9aa	539	-310	no	40	228	148	308	AA	AA	AA	TMLVTA	-7.8	0.3	30.5	228.0
206	Ochre	U-3ec	490	-363	no	47	126	32	220	AA	AA	AA	TMLVTA	-7.7			
411	Truchas-Chamisal	U-3ho	475	-357	no	47	118	24	212	AA	AA	AA	TMLVTA	-7.6			
410	Truchas-Chacon	U-3hn	475	-356	no	47	119	25	213	AA	AA	AA	TMLVTA	-7.6			
24	Cimarron	U-9h	539	-235	no	31	305	243	367	AA	AA	AA	TMLVTA	-7.6	11.0	141.4	293.8
426	Dexter	U-3hs	475	-354	no	47	120	26	214	AA	AA	AA	TMLVTA	-7.5			
225	Ajax	U-9aL	537	-299	no	40	238	158	318	AA	AA	AA	TMLVTA	-7.5	13.7	121.9	224.7
467	Solano	U-3jx	468	-334	no	46	134	42	226	AA	AA	AA	TMLVTA	-7.3			
32	Dormouse Prime	U-3az	490	-230	no	32	261	197	325	AA	AA	AA	TMLVTA	-7.2	29.7	158.5	231.2
499	Spar	U-3jr	471	-322	no	45	148	58	238	AA	AA	AA	TMLVTA	-7.2			
455	Jicarilla	U-3jm	470	-322	no	45	148	58	238	AA	AA	AA	TMLVTA	-7.2			
487	Mesita	U-3jd	470	-321	no	45	149	59	239	AA	AA	AA	TMLVTA	-7.1			
458	Zinnia	U-2dk	563	-240	no	37	323	249	397	AA	AA	AA	TMLVTA	-6.5	14.6	101.8	308.2
69	Casselman	U-10g	549	-246	no	38	303	227	379	AA	AA	AA	TMLVTA	-6.5	22.3	135.9	280.7
53	Peba	U-3bb	499	-258	no	40	241	161	321	AA	AA	AA	TMLVTA	-6.4	27.9	170.7	213.5
574	Rib	U-3jv	477	-264	no	41	213	131	295	AA	AA	AA	TMLVTA	-6.4	6.1	91.4	206.7
453	Ocate	U-3jp	469	-259	no	41	210	128	292	AA	AA	AA	TMLVTA	-6.3	7.7	94.5	202.3
456	Longchamps	U-2dm	560	-233	no	37	326	252	400	AA	AA	AA	TMLVTA	-6.3	21.7	46.9	304.7
60	Santee	U-10f	551	-232	no	37	319	245	393	AA	AA	AA	TMLVTA	-6.3	6.4	121.9	313.0
441	Chantilly	U-2di	562	-231	no	37	331	257	405	AA	AA	AA	TMLVTA	-6.3			
62	Gundi	U-3bm	489	-248	no	40	241	161	321	AA	AA	AA	TMLVTA	-6.2	4.0	82.3	237.4
256	Gilroy	U-3ex	485	-245	no	40	240	160	320	AA	AA	AA	TMLVTA	-6.1			
278	Hatchet	U-3fz	482	-241	no	40	240	160	320	AA	AA	AA	TMLVTA	-6.0	14.4	160.3	226.1
590	Concentration	U-3kn	483	-240	no	40	243	163	323	AA	AA	AA	TMLVTA	-6.0	5.1	100.6	237.9

Appendix C

YFDB Identifier	Detonation Name[a]	Hole Name[a]	Water Level (WL) Depth[b] (m)	WP minus WL (m)	Saturated Test?	Calculated Cavity Radius (Rc)[c] (m)	WP Depth[d] (m)	WP-2Rc (m)	WP+2Rc (m)	WP HSU[e]	WP-2Rc HSU[e]	WP+ 2Rc HSU[e]	HSU at Water Table[e]	Distance WP to WL, in Rc (m)	Crater Depth[d] (m)	Crater Diameter[d] (m)	Distance WP to Bottom of Crater (m)
248	Umber	U-3em	482	-172	no	30	310	250	370	AA	AA	AA	TMLVTA	-5.7	24.2	165.2	286.1
485	Colmor	U-3hv	475	-229	no	40	246	166	326	AA	AA	AA	TMLVTA	-5.7	3.0	69.5	242.7
650	Crowdie	U-2fe	590	-200	no	35	390	320	460	AA	AA	AA	TMLVTA	-5.7	12.5	81.5	377.6
305	Crew-2nd	U-2db	561	-203	no	36	359	287	431	AA	AA	AA	TMLVTA	-5.6	18.3	121.9	340.4
474	Tuloso	U-3gi	483	-212	no	39	271	193	349	AA	AA	AA	TMLVTA	-5.4			
605	Tarko	U-2fd	561	-193	no	36	369	297	441	AA	AA	AA	TMLVTA	-5.4	13.6	91.6	354.9
693	Cornucopia	U-2gaS	566	-185	no	35	380	310	450	AA	AA	AA	TMLVTA	-5.3	16.9	137.5	363.5
115	Bonefish	U-3bt	498	-197	no	38	301	225	377	AA	AA	AA	TMLVTA	-5.2	23.2	173.7	277.6
454	Onaja	U-3js	471	-192	no	38	279	203	355	AA	AA	AA	TMLVTA	-5.0	22.1	137.2	256.8
145	Par	U-2p	586	-180	no	43	406	320	492	AA	AA	AA	TMLVTA	-4.2	21.8	144.8	383.9
446	Chaenactis	U-2dL	565	-234	no	79	331	173	489	AA	AA	AA	TMLVTA	-3.0	12.6	113.4	318.4
304	Crew	U-2db	561	-203	no	77	359	205	513	AA	AA	AA	TMLVTA	-2.6	18.3	121.9	340.4
653	Laban	U-2ff	561	-235	no	37	326	252	400	AA	AA	TMLVTA	TMLVTA	-6.4	46.6	42.0	279.5
105	Greys	U-9ax	533	-232	no	81	301	139	463	AA	AA	TMLVTA	TMLVTA	-2.9	12.8	121.9	288.3
275	Noor	U-2be	596	-214	no	76	382	230	534	AA	AA	TMLVTA	TMLVTA	-2.8	10.9	158.5	371.0
380	Yannigan-White	U-2ay #2	523	-128	no	76	395	243	547	AA	AA	TMLVTA	TMLVTA	-1.7	32.3	219.5	362.4
465	Cebolla	U-3jc	472	-185	no	38	287	211	363	AA	AA	TMUVTA	TMLVTA	-4.9			
536	Deck	U-3kd	472	-146	no	37	326	252	400	AA	AA	TMUVTA	TMLVTA	-4.0	15.7	183.2	310.4
74	Kaweah	U-9ab	534	-307	no	21	227	185	269	AA	AA	TMWTA	TMLVTA	-14.6			
125	Driver	U-9ar	543	-395	no	45	148	58	238	AA	AA	TMWTA	TMLVTA	-8.8			
87	Pleasant	U-9ah	540	-329	no	41	211	129	293	AA	AA	TMWTA	TMLVTA	-8.0	2.4	48.8	208.5
33	Passaic	U-9L	536	-303	no	40	233	153	313	AA	AA	TMWTA	TMLVTA	-7.6	21.3	152.4	212.2
505	Sapello	U-3ge	482	-302	no	43	181	95	267	AA	AA	TMWTA	TMLVTA	-7.0			
565	Gruyere-Gradino	U-9cg	545	-225	no	37	320	246	394	AA	AA	TMWTA	TMLVTA	-6.1			
656	Branco	U-2ew	520	-227	no	38	293	217	369	AA	AA	TMWTA	TMLVTA	-6.0	9.7	111.7	282.9
311	Scissors	U-3gh	475	-235	no	40	240	160	320	AA	AA	TMWTA	TMLVTA	-5.9	13.4	119.5	227.1
416	Corazon	U-3ha	474	-233	no	40	241	161	321	AA	AA	TMWTA	TMLVTA	-5.8			
414	Penasco	U-3hL	475	-204	no	39	271	193	349	AA	AA	TMWTA	TMLVTA	-5.2	14.8	140.6	256.2
464	Atarque	U-3ht	474	-179	no	38	294	218	370	AA	AA	TMWTA	TMLVTA	-4.7	5.0	120.4	289.4
235	Persimmon	U-3dn	476	-177	no	38	299	223	375	AA	AA	TMWTA	TMLVTA	-4.7	6.1	170.7	292.9
523	Keel	U-3hu	473	-169	no	37	305	231	379	AA	AA	TMWTA	TMLVTA	-4.6	19.6	157.0	285.2
199	Clymer	U-9ce	546	-149	no	35	397	327	467	AA	AA	TMWTA	TMLVTA	-4.2	1.6	87.8	395.6
635	Kryddost	U-2co	516	-180	no	37	335	261	409	TMLVTA	TMLVTA	TMLVTA	TMLVTA	-4.9			
682	Maribo	U-2cs	547	-166	no	35	381	311	451	TMLVTA	TMLVTA	TMLVTA	TMLVTA	-4.7			
724	Palisade-1	U-4at	490	-155	no	37	335	261	409	TMLVTA	TMLVTA	TMLVTA	TMLVTA	-4.2	7.7	92.8	327.6
707	Abilene	U-3mn	481	-236	no	40	245	165	325	TMUVTA	AA	TMLVTA	TMLVTA	-5.9	7.9	96.9	237.2
660	Muggins	U-3Ls	482	-238	no	40	244	164	324	TMUVTA	AA	TMWTA	TMLVTA	-5.9	11.0	95.2	232.8
677	Minero	U-3Lt	481	-237	no	40	245	165	325	TMUVTA	AA	TMWTA	TMLVTA	-5.9	11.6	108.5	233.2
690	Mogollon	U-3Li	481	-221	no	39	259	181	337	TMUVTA	AA	TMWTA	TMLVTA	-5.7	5.2	88.1	254.2
626	Trebbiano	U-3Lj	486	-181	no	37	305	231	379	TMUVTA	AA	TMWTA	TMLVTA	-4.9			
520	Estaca	U-3ja	470	-149	no	37	321	247	395	TMUVTA	AA	TMWTA	TMLVTA	-4.0			
613	Bonarda	U-3gv	490	-109	no	69	381	243	519	TMWTA	AA	LTCU	TMLVTA	-1.6	10.9	67.7	370.1
340	Ildrim	U-2au	514	-104	no	75	410	260	560	TMWTA	AA	TMLVTA	TMLVTA	-1.4	9.1	152.4	401.2
323	Winch	U-3gf	479	-239	no	40	240	160	320	TMWTA	AA	TMWTA	TMLVTA	-6.0			
415	Carrizozo	U-3hr	477	-198	no	38	279	203	355	TMWTA	AA	TMWTA	TMLVTA	-5.2			
699	Tornero	U-3LL	480	-182	no	38	298	222	374	TMWTA	TMUVTA	TMWTA	TMLVTA	-4.8	9.1	132.6	289.3

YFDB Identifier	Detonation Name[a]	Hole Name[a]	Water Level (WL) Depth[b] (m)	WP minus WL (m)	Saturated Test?	Calculated Cavity Radius (Rc)[c] (m)	WP Depth[d] (m)	WP-2Rc (m)	WP+2Rc (m)	WP HSU[e]	WP-2Rc HSU[e]	WP+ 2Rc HSU[e]	HSU at Water Table[e]	Distance WP to WL, in Rc (m)	Crater Depth[d] (m)	Crater Diameter[d] (m)	Distance WP to Bottom of Crater (m)
4	Otero	U-3q	496	-350	no	6	146	134	158	AA	AA	AA	TMUVTA	-58.3			
302	Bit-B	U-3gt	493	-375	no	47	118	24	212	AA	AA	AA	TMUVTA	-8.0			
288	Funnel	U-3ga	493	-375	no	47	119	25	213	AA	AA	AA	TMUVTA	-8.0			
220	Tangerine	U-3eb	492	-404	no	51	88	-14	190	AA	AA	AA	TMUVTA	-7.9			
79	Coypu	U-3af	495	-420	no	53	75	-31	181	AA	AA	AA	TMUVTA	-7.9			
3	Pascal-C	U-3e	496	-419	no	53	76	-30	182	AA	AA	AA	TMUVTA	-7.9			
449	Mescalero	U-3gu	492	-372	no	47	120	26	214	AA	AA	AA	TMUVTA	-7.9			
310	Bay Leaf	U-3gq	493	-363	no	46	130	38	222	AA	AA	AA	TMUVTA	-7.9			
238	Fizz	U-3fr	493	-376	no	48	117	22	214	AA	AA	AA	TMUVTA	-7.8			
298	Welder	U-3fs	493	-375	no	48	118	22	214	AA	AA	AA	TMUVTA	-7.8			
301	Bit-A	U-3gt	493	-344	no	45	148	58	238	AA	AA	AA	TMUVTA	-7.6			
147	Turnstone	U-3dt	485	-359	no	47	126	32	220	AA	AA	AA	TMUVTA	-7.6			
12	Mink	U-3ae	495	-303	no	42	192	108	276	AA	AA	AA	TMUVTA	-7.2	1.5	15.2	190.5
461	Capitan	U-3jj	465	-330	no	46	134	42	226	AA	AA	AA	TMUVTA	-7.2			
627	Cernada	U-3kk	473	-260	no	41	213	131	295	AA	AA	AA	TMUVTA	-6.3	1.2	37.2	211.9
735	Sundown-B	U-1d	495	-239	no	39	256	178	334	AA	AA	AA	TMUVTA	-6.1			
603	Backgammon	U-3jh	466	-237	no	40	229	149	309	AA	AA	AA	TMUVTA	-5.9	8.8	112.8	219.8
124	Pipefish	U-3co	488	-226	no	39	262	184	340	AA	AA	AA	TMUVTA	-5.8	22.0	146.3	239.8
734	Sundown-A	U-1d	495	-224	no	39	270	192	348	AA	AA	AA	TMUVTA	-5.8			
495	Bernal	U-3jy	475	-190	no	38	285	209	361	AA	AA	AA	TMUVTA	-5.0	21.8	150.3	263.5
496	Pajara	U-3ji	465	-187	no	38	278	202	354	AA	AA	AA	TMUVTA	-4.9	37.8	137.2	240.5
385	Jal	U-3hh	469	-167	no	38	301	225	377	AA	AA	AA	TMUVTA	-4.4	10.9	142.6	290.5
448	Yerba	U-1c	490	-158	no	37	332	258	406	AA	AA	AA	TMUVTA	-4.3	17.4	111.9	314.5
527	Bilge	U-3kc	470	-152	no	37	318	244	392	AA	AA	AA	TMUVTA	-4.1			
612	Verdello	U-3ku	476	-110	no	36	366	294	438	AA	AA	TMUVTA	TMUVTA	-3.1	12.8	184.2	353.0
379	Yannigan-Red	U-2ay #1	508	-116	no	76	392	240	544	AA	AA	TMWTA	TMUVTA	-1.5	44.2	217.9	347.8
7	Valencia	U-3r	495	-347	no	2	148	144	152	AA	AA	AA	TMWTA	-173.7			
399	Flask-Red	U-2az #3	518	-365	no	5	152	142	162	AA	AA	AA	TMWTA	-73.0			
22	Chinchilla	U-3ag	495	-345	no	20	150	110	190	AA	AA	AA	TMWTA	-17.3	12.7	95.7	137.3
153	Drill (Target-Upper)	U-2ai	557	-369	no	23	188	142	234	AA	AA	AA	TMWTA	-16.0	10.7	19.2	177.4
177	Pongee	U-2ah	553	-419	no	46	134	42	226	AA	AA	AA	TMWTA	-9.1			
102	Mullet	U-2ag	552	-492	no	56	60	-52	172	AA	AA	AA	TMWTA	-8.8			
152	Drill (Source-Lower)	U-2ai	557	-338	no	41	219	136	301	AA	AA	AA	TMWTA	-8.3	10.7	19.2	208.1
91	Kennebec	U-2af	554	-328	no	40	226	146	306	AA	AA	AA	TMWTA	-8.2	12.2	109.7	214.0
209	Tapestry	U-2an	557	-309	no	39	249	171	327	AA	AA	AA	TMWTA	-7.9	7.3	91.4	241.4
154	Cassowary	U-3bn	488	-337	no	45	150	60	240	AA	AA	AA	TMWTA	-7.5			
49	Bobac	U-3bL	492	-286	no	41	206	124	288	AA	AA	AA	TMWTA	-7.0	13.5	121.9	192.5
466	Cuchillo	U-3jt	469	-271	no	42	199	115	283	AA	AA	AA	TMWTA	-6.4			
78	Ferret Prime	U-3by	487	-245	no	40	241	161	321	AA	AA	AA	TMWTA	-6.1	34.7	144.5	206.7
37	Paca	U-3ax	492	-233	no	39	258	180	336	AA	AA	AA	TMWTA	-6.0	18.8	138.4	239.7
141	Guanay	U-3di	478	-217	no	39	261	183	339	AA	AA	AA	TMWTA	-5.6	22.6	137.2	238.3
65	Tendrac	U-3ba	496	-194	no	38	303	227	379	AA	AA	AA	TMWTA	-5.1	24.7	155.4	278.0
75	Jerboa	U-3at	491	-190	no	38	301	225	377	AA	AA	AA	TMWTA	-5.0	32.2	168.9	268.9
484	Velarde	U-3jk	465	-188	no	38	277	201	353	AA	AA	AA	TMWTA	-5.0	26.8	137.8	250.0
716	Monahans-A	U-3Lk	463	-173	no	38	290	214	366	AA	AA	AA	TMWTA	-4.6			
712	Harlingen-A	U-6g	463	-173	no	38	290	214	366	AA	AA	AA	TMWTA	-4.6	11.8	62.6	277.8

YFDB Identifier	Detonation Name[a]	Hole Name[a]	Water Level (WL) Depth[b] (m)	WP minus WL (m)	Saturated Test?	Calculated Cavity Radius (Rc)[c] (m)	WP Depth[d] (m)	WP-2Rc (m)	WP+2Rc (m)	WP HSU[e]	WP-2Rc HSU[e]	WP+ 2Rc HSU[e]	HSU at Water Table[e]	Distance WP to WL, in Rc (m)	Crater Depth[d] (m)	Crater Diameter[d] (m)	Distance WP to Bottom of Crater (m)
713	Harlingen-B	U-6h	462	-173	no	38	290	214	366	AA	AA	AA	TMWTA	-4.5			
717	Monahans-B	U-6i	462	-173	no	38	290	214	366	AA	AA	AA	TMWTA	-4.5			
450	Cowles	U-3hx	468	-166	no	38	302	226	378	AA	AA	AA	TMWTA	-4.4	9.6	157.3	292.2
13	Fisher	U-3ah	492	-128	no	31	364	302	426	AA	AA	AA	TMWTA	-4.1	15.1	178.0	348.5
438	Frijoles-Espuela	U-3ju	479	-329	no	45	149	59	239	AA	AA	AA	TSA	-7.3			
437	Frijoles-Deming	U-3jw	478	-328	no	45	150	60	240	AA	AA	AA	TSA	-7.3			
641	Cerro	U-3Lf	478	-249	no	40	229	149	309	AA	AA	AA	TSA	-6.2	0.9	33.5	227.7
412	Truchas-Rodarte	U-3hm	476	-209	no	39	266	188	344	AA	AA	AA	TSA	-5.4	9.3	132.3	257.1
702	Panchuela	U-3mg	473	-154	no	37	319	245	393	AA	AA	TMUVTA	TMWTA	-4.2	21.0	166.7	298.1
595	Freezeout	U-3kw	466	-131	no	37	335	261	409	AA	AA	TMUVTA	TMWTA	-3.5	12.5	189.3	322.8
15	Ringtail	U-3ak	490	-127	no	36	363	291	435	AA	AA	TMUVTA	TMWTA	-3.5	0.7	121.9	362.3
572	Seamount	U-3kp	479	-109	no	36	370	298	442	AA	AA	TMUVTA	TMWTA	-3.0	17.2	211.2	352.8
269	Mallet	U-3fv	465	-225	no	40	240	160	320	AA	AA	TMUVTA	TSA	-5.6	19.9	131.1	220.3
378	Yannigan-Blue	U-2ay #3	510	-147	no	77	364	210	518	AA	AA	TMWTA	TMWTA	-1.9	33.5	207.3	330.1
272	Russet	U-6a	459	-340	no	47	120	26	214	AA	AA	AA	TMWTA	-7.2			
684	Chamita	U-3Lz	475	-144	no	37	332	258	406	TMUVTA	AA	TMWTA	TMWTA	-3.9	20.7	151.7	310.9
675	Vermejo	U-4r	467	-117	no	36	350	278	422	TMUVTA	AA	TMWTA	TMWTA	-3.2	3.4	51.2	346.8
200	Purple	U-3ds	469	-137	no	37	333	259	407	TMWTA	AA	TMLVTA	TSA	-3.7	12.0	139.6	320.8
355	Pod-C[f]	U-2ci	466	-296	no	26	171	119	223	AA	AA	TMLVTA	UCCU	-7.2			
230	Nash	U-2ce	527	-163	no	45	364	274	454	LCA3	TMLVTA	LCA3	UCCU	-3.6	54.9	152.4	309.0
218	Saxon	U-2cc	536	-383	no	17	154	120	188	TMLVTA	AA	TMLVTA	UCCU	-22.5	7.6	23.8	146.0
354	Pod-B[f]	U-2ch	444	-195	no	24	249	201	297	TMLVTA	TMLVTA	LTCU	UCCU	-5.3			
673	Wexford	U-2cr	558	-244	no	37	314	240	388	TMLVTA	TMLVTA	TMLVTA	UCCU	-6.6	4.1	39.7	309.8
522	Puddle	U-3kg	481	-298	no	43	183	97	269	AA	AA	AA	UTCU	-6.9			
322	Nipper	U-3gL	466	-225	no	40	241	161	321	AA	AA	TMUVTA	UTCU	-5.6	2.9	87.2	237.9
743	Victoria	U-3kv	468	-223	no	40	244	164	324	AA	AA	TMUVTA	UTCU	-5.6			

DETONATIONS WITH WORKING POINT ABOVE THE WATER TABLE, BUT BELOW THE "SATURATED ZONE"

YFDB Identifier	Detonation Name[a]	Hole Name[a]	Water Level (WL) Depth[b] (m)	WP minus WL (m)	Saturated Test?	Calculated Cavity Radius (Rc)[c] (m)	WP Depth[d] (m)	WP-2Rc (m)	WP+2Rc (m)	WP HSU[e]	WP-2Rc HSU[e]	WP+ 2Rc HSU[e]	HSU at Water Table[e]	Distance WP to WL, in Rc (m)	Crater Depth[d] (m)	Crater Diameter[d] (m)	Distance WP to Bottom of Crater (m)
529	Cabrillo	U-2dr	566	34	yes	68	600	464	736	AA	AA	TMLVTA	AA	0.5	14.3	198.1	586.2
573	Farallones	U-2fa	570	97	yes	60	667	547	787	AA	AA	TMLVTA	AA	1.6	26.3	305.4	640.9
306	Crew-3rd	U-2db	561	41	yes	32	603	539	667	TMLVTA	AA	TMLVTA	AA	1.3	18.3	121.9	584.3
423	Carpetbag	U-2dg	552	109	yes	69	661	523	799	TMLVTA	AA	TMLVTA	AA	1.6	33.5	294.4	627.9
234	Agile	U-2v	543	190	yes	65	733	603	863	TMLVTA	TMWTA	LTCU	AA	2.9	12.2	274.3	721.1
436	Algodones	U-3jn	497	31	yes	70	528	388	668	TMUVTA	AA	TMWTA	AA	0.4	10.0	261.8	517.6
330	Blenton	U-7p	536	22	yes	69	558	420	696	LTCU	LTCU	ATCU	LTCU	0.3			
643	Borrego	U-7br	493	70	yes	63	563	437	689	LTCU	LTCU	ATCU	LTCU	1.1			
532	Mizzen	U-7ah	536	101	yes	67	637	503	771	LTCU	LTCU	ATCU	LTCU	1.5	32.6	253.9	604.4
680	Hermosa	U-7bs	541	97	yes	61	638	516	760	LTCU	LTCU	ATCU	LTCU	1.6	45.8	384.7	592.5
617	Baseball	U-7ba	458	105	yes	63	564	438	690	LTCU	LTCU	ATCU	LTCU	1.7	17.6	215.5	546.3
630	Rousanne	U-4p	499	19	yes	64	517	389	645	LTCU	LTCU	LTCU	LTCU	0.3	18.3	243.8	498.9
221	Daiquiri	U-7o	550	11	yes	32	561	497	625	LTCU	LTCU	LTCU	LTCU	0.3			
429	Miniata	U-2bu	494	35	yes	52	529	425	633	LTCU	LTCU	LTCU	LTCU	0.7	32.0	245.7	496.8

YFDB Identifier	Detonation Name[a]	Hole Name[a]	Water Level (WL) Depth[b] (m)	WP minus WL (m)	Saturated Test?	Calculated Cavity Radius (Rc)[c] (m)	WP Depth[d] (m)	WP-2Rc (m)	WP+2Rc (m)	WP HSU[e]	WP-2Rc HSU[e]	WP+ 2Rc HSU[e]	HSU at Water Table[e]	Distance WP to WL, in Rc (m)	Crater Depth[d] (m)	Crater Diameter[d] (m)	Distance WP to Bottom of Crater (m)
636	Bouschet	U-3La	479	85	yes	63	564	438	690	LTCU	LTCU	LTCU	LTCU	1.3	17.4	204.8	546.5
588	Rummy	U-7au	489	151	yes	61	640	518	762	LTCU	LTCU	LTCU	LTCU	2.5	15.8	390.7	624.0
633	Jornada	U-4j	477	162	yes	59	639	521	757	LTCU	LTCU	LTCU	LTCU	2.7	26.5	399.6	612.4
601	Hearts	U-4n	473	167	yes	60	640	520	760	LTCU	LTCU	LTCU	LTCU	2.8	32.6	332.5	607.5
571	Sandreef	U-7aq	479	222	yes	60	701	581	821	LTCU	LTCU	LTCU	LTCU	3.7	14.3	230.4	686.4
581	Transom	U-4f	472	168	yes	0	640	640	640	LTCU	LTCU	LTCU	LTCU	no cavity			
658	Techado	U-4o	493	40	yes	64	532	404	660	LTCU	LTCU	OSBCU	LTCU	0.6			
559	Crewline	U-7ap	498	66	yes	63	564	438	690	LTCU	LTCU	OSBCU	LTCU	1.1			
584	Lowball	U-7av	490	75	yes	63	565	439	691	LTCU	LTCU	OSBCU	LTCU	1.2	22.7	274.3	542.1
539	Esrom	U-7ak	548	107	yes	67	655	521	789	LTCU	LTCU	OSBCU	LTCU	1.6	51.8	217.7	603.2
695	Gascon	U-4t	490	103	yes	62	593	469	717	LTCU	LTCU	OSBCU	LTCU	1.7	32.9	287.7	560.2
668	Caprock	U-4q	493	107	yes	62	600	476	724	LTCU	LTCU	OSBCU	LTCU	1.7	50.3	249.3	549.5
512	Escabosa	U-7ac	513	125	yes	67	639	505	773	LTCU	LTCU	OSBCU	LTCU	1.9	23.0	351.1	615.6
540	Keelson	U-7ai	508	131	yes	67	639	505	773	LTCU	LTCU	OSBCU	LTCU	2.0	11.3	359.7	628.2
270	Knox	U-2at	504	141	yes	67	645	511	779	LTCU	LTCU	OSBCU	LTCU	2.1	33.5	336.8	611.5
503	Latir	U-4d	486	155	yes	67	641	507	775	LTCU	LTCU	OSBCU	LTCU	2.3	24.1	267.0	616.6
544	Billet	U-7an	487	150	yes	61	636	514	758	LTCU	LTCU	OSBCU	LTCU	2.5			
704	Tahoka	U-3mf	487	151	yes	61	639	517	761	LTCU	LTCU	OSBCU	LTCU	2.5	22.6	314.6	616.0
578	Iceberg	U-4g	485	155	yes	61	640	518	762	LTCU	LTCU	OSBCU	LTCU	2.5	24.4	276.7	616.0
715	Dalhart	U-4u	477	162	yes	61	640	518	762	LTCU	LTCU	OSBCU	LTCU	2.7			
663	Tortugas	U-3gg	474	165	yes	61	639	517	761	LTCU	LTCU	OSBCU	LTCU	2.7	20.1	270.8	618.5
538	Chiberta	U-2ek	540	176	yes	65	716	586	846	LTCU	LTCU	OSBCU	LTCU	2.7	35.4	343.8	680.9
258	Zaza	U-4c	488	179	yes	66	667	535	799	LTCU	LTCU	OSBCU	LTCU	2.7	28.4	302.4	638.5
528	Topgallant	U-4e	483	230	yes	65	713	583	843	LTCU	LTCU	OSBCU	LTCU	3.5	19.9	297.6	693.3
263	Cobbler	U-7u	531	136	yes	31	667	605	729	LTCU	LTCU	OSBCU	LTCU	4.4			
648	Turquoise	U-7bu	480	53	yes	64	533	405	661	LTCU	TMLVTA	LTCU	LTCU	0.8	14.6	233.5	518.5
688	Kinibito	U-3me	496	84	yes	62	579	455	703	LTCU	TMLVTA	LTCU	LTCU	1.4	11.1	216.4	568.3
592	Quinella	U-4L	484	95	yes	62	579	455	703	LTCU	TMLVTA	LTCU	LTCU	1.5	29.6	299.9	549.5
210	Piranha	U-7e	526	22	yes	70	549	409	689	LTCU	TMLVTA	OSBCU	LTCU	0.3	24.8	339.5	523.8
245	Commodore	U-2am	549	196	yes	69	745	607	883	LTCU	TMLVTA	OSBCU	LTCU	2.8	45.1	328.7	700.1
259	Lanpher	U-2x	498	217	yes	65	715	585	845	LTCU	TMLVTA	OSBCU	LTCU	3.3	14.9	298.7	700.2
468	Oscuro	U-7z	513	47	yes	69	560	422	698	LTCU	TMWTA	LTCU	LTCU	0.7	24.6	408.4	535.6
486	Starwort	U-2bs	525	39	yes	53	564	458	670	LTCU	TMWTA	LTCU	LTCU	0.7	22.2	349.3	541.7
576	Reblochon	U-2en	534	124	yes	60	658	538	778	LTCU	TMWTA	LTCU	LTCU	2.1	27.8	343.2	630.6
557	Marsilly	U-2eL	520	169	yes	60	689	569	809	LTCU	TMWTA	LTCU	LTCU	2.8	27.6	334.4	661.2
164	Wagtail	U-3an	492	258	yes	64	750	622	878	LTCU	TMWTA	LTCU	LTCU	4.0			
211	Dumont	U-2t	486	185	yes	66	671	539	803	LTCU	TMWTA	OSBCU	LTCU	2.8	33.5	359.7	637.4
558	Bulkhead	U-7am	551	43	yes	62	594	470	718	OSBCU	LTCU	ATCU	LTCU	0.7	5.8	271.3	588.6
639	Atrisco	U-7bp	538	102	yes	59	640	522	758	OSBCU	LTCU	ATCU	LTCU	1.7	33.5	359.4	606.3
97	Bilby	U-3cn	509	205	yes	70	714	574	854	OSBCU	LTCU	ATCU	LTCU	2.9	26.2	450.8	688.3
21	Hard Hat	U-15a	222	66	yes	25	287	237	337	MGCU	MGCU	MGCU	MGCU	2.6			
213	Pile Driver	U-15.01	185	277	yes	49	463	365	561	MGCU	MGCU	MGCU	MGCU	5.7			
490	Potrillo	U-7af	548	19	yes	69	567	429	705	OSBCU	LTCU	ATCU	OSBCU	0.3	13.2	331.6	553.7
366	Grape A	U-7s	539	12	yes	70	551	411	691	OSBCU	LTCU	LCA	OSBCU	0.2	13.9	335.9	536.9
542	Strait	U-4a	484	298	yes	87	782	608	956	OSBCU	LTCU	LCA	OSBCU	3.4	41.2	209.8	741.2
331	Thistle	U-7t	556	5	yes	69	561	423	699	OSBCU	LTCU	OSBCU	OSBCU	0.1			

Appendix C

YFDB Identifier	Detonation Name[a]	Hole Name[a]	Water Level (WL) Depth[b] (m)	WP minus WL (m)	Saturated Test?	Calculated Cavity Radius (Rc)[c] (m)	WP Depth[d] (m)	WP-2Rc (m)	WP+2Rc (m)	WP HSU[e]	WP-2Rc HSU[e]	WP+ 2Rc HSU[e]	HSU at Water Table[e]	Distance WP to WL, in Rc (m)	Crater Depth[d] (m)	Crater Diameter[d] (m)	Distance WP to Bottom of Crater (m)
608	Pyramid	U-7be	557	22	yes	62	579	455	703	OSBCU	LTCU	OSBCU	OSBCU	0.4	18.6	337.1	560.5
459	Monero	U-3jq	522	15	yes	32	537	473	601	OSBCU	LTCU	OSBCU	OSBCU	0.5			
409	Tijeras	U-7y	523	37	yes	69	561	423	699	OSBCU	LTCU	OSBCU	OSBCU	0.5	53.5	308.0	507.0
552	Rudder	U-7ajS	544	94	yes	61	639	517	761	OSBCU	LTCU	OSBCU	OSBCU	1.5	13.8	362.4	624.8
689	Glencoe	U-4i	493	117	yes	36	610	538	682	OSBCU	LTCU	OSBCU	OSBCU	3.2			
566	Scantling	U-4h	482	219	yes	60	701	581	821	OSBCU	LTCU	OSBCU	OSBCU	3.7	28.7	275.8	672.3
192	Lampblack	U-7i	560	2	yes	69	561	423	699	OSBCU	OSBCU	LCA	OSBCU	0.0			
386	Shaper	U-7r	545	16	yes	69	561	423	699	OSBCU	OSBCU	LCA	OSBCU	0.2	22.1	329.7	538.4
188	Corduroy	U-10k	568	111	yes	66	679	547	811	OSBCU	OSBCU	LCA	OSBCU	1.7	30.5	243.8	648.3
351	Calabash	U-2av	569	55	yes	55	625	515	735	LTCU	TMLVTA	LCA	TMLVTA	1.0	17.9	271.5	606.9
516	Portmanteau	U-2ax	600	55	yes	67	655	521	789	TMLVTA	AA	OSBCU	TMLVTA	0.8	30.0	266.7	625.3
589	Quargel	U-2fb	539	3	yes	63	542	416	668	TMLVTA	AA	TMLVTA	TMLVTA	0.1	25.7	239.6	516.2
477	Flax-Source	U-2dj	577	111	yes	30	688	628	748	TMLVTA	AA	TMLVTA	TMLVTA	3.7	28.0	178.0	660.2
214	Tan	U-7k	499	62	yes	69	561	423	699	TMLVTA	TMUVTA	LTCU	TMLVTA	0.9	21.2	415.1	539.6
294	Noggin	U-9bx	543	38	yes	69	582	444	720	TMLVTA	TMWTA	LTCU	TMLVTA	0.6	55.5	304.8	526.4
398	Flask-Green	U-2az #1	497	32	yes	57	529	415	643	TMUVTA	TMUVTA	TMWTA	TMUVTA	0.6	48.8	297.2	479.7
694	Aleman	U-3kz	475	28	yes	33	503	437	569	TMLVTA	TMWTA	LTCU	TMWTA	0.8			
518	Stanyan	U-2aw	554	19	yes	69	573	435	711	TMWTA	AA	LTCU	TMWTA	0.3	21.0	281.8	552.0

[a]DOE/NV--209-Rev 15, as described in this report

[b]Derived from the Yucca Flat EarthVision® hydrostratigraphic model

[c]Calculated cavity radius from [70.2 * Max Yield$^{1/3}$ (kt)] / [overburden density (Mg/m^3) * WP depth (m)]$^{1/4}$, using yield from USDOE, 2000b

[d]LLNL Containment Data Base

[e]HSU information is derived from various data bases and/or the EarthVision® hydrostratigraphic model

[f]DOE/NV--209 Rev 15 states yield for Pod-A, Pod-B, Pod-C, and Pod-D as 16.7 kt (Total). This yield was simply divided by 4 and the result applied to each detonation.